VOL. XI, PART I QUARTERLY *JANUARY, 1916*

THE AGRICULTURAL JOURNAL OF INDIA

AGRICULTURAL RESEARCH INSTITUTE, PUSA

PUBLISHED FOR
THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA
BY
THACKER, SPINK & CO., CALCUTTA
W. THACKER & CO., 2, CREED LANE, LONDON

Agents for the Sale of Government Publications

IN THE UNITED KINGDOM.

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.

Kegan Paul, Trench Trübner & Co., 68-74, Carter Lane, E.C., and 25, Museum Street, London, W.C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.

P. S. King & Son, 2 and 4, Great Smith Street, Westminster, London, S.W.

H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, London, W.

Grindlay & Co., 54, Parliament Street, London, S.W.

T. Fisher Unwin, Limited, 1, Adelphi Terrace, London, W.C.

W. Thacker & Co., 2, Creed Lane, London, E.C.

Luzac & Co., 46, Great Russell Street, London, W.C.

B. H. Blackwell, 50 and 51, Broad Street, Oxford.

Deighton, Bell & Co., Ltd., Cambridge.

Oliver & Boyd, Tweeddale Court, Edinburgh.

E. Ponsonby, Ltd., 116, Grafton Street, Dublin.

ON THE CONTINENT.

Ernest Leroux, 28, Rue Bonaparte, Paris.

Martinus Nijhoff, The Hague, Holland.

IN INDIA AND CEYLON.

Thacker, Spink & Co., Calcutta and Simla.

W. Newman & Co., Calcutta

R. Cambray & Co., Calcutta.

S. K. Lahiri & Co., Calcutta.

B. Bannerjee & Co., Calcutta.

The Calcutta School Book and Useful Literature Society, 309, Bow Bazar Street, Calcutta, and 226, Nawabpur, Dacca.

Butterworth & Co. (India), Limited, Calcutta.

The Weldon Library, 18-5, Chowringhee Road, Calcutta.

Rai M. C. Sircar Bahadur & Sons, 75-1-1, Harrison Road, Calcutta.

Higginbothams, Ltd., Madras.

V. Kalyanarama Iyer & Co., Madras.

G. A. Natesan & Co., Madras.

S. Murthy & Co., Madras.

Thompson & Co., Madras.

Temple & Co., Madras.

Combridge & Co., Madras.

P. R. Rama Iyer & Co., Madras.

Thacker & Co., Ld., Bombay.

A. J. Combridge & Co., Bombay.

D. B. Taraporevala Sons & Co., Bombay.

Radhabai Atmaram Sagoon, Bombay.

Sunder Pandurang, Bombay.

Gopal Narayan & Co., Bombay.

Ramchandra Govind & Son, Kalbadevi, Bombay.

N. B. Mathur, Superintendent, Nazir Kanun-i-Hind Press, Allahabad.

A. Chand & Co., Lahore, Punjab.

Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore and Calcutta.

Superintendent, American Baptist Mission Press, Rangoon.

S. C. Talukdar, Proprietor, tudents and Company, Cooch Behar.

A. M. & J. Ferguson, Colombo, Ceylon.

CONTENTS

		Page
Education in its Relation to Agriculture	*B. Coventry, C.I.E.*	1
The Saving of Irrigation Water in Wheat Growing	*Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A.* ...	14
Indian Hemp Fibre	*C. D'Lima* ...	31
The Indian Sugar Industry	*Wynne Sayer, B.A.*	42
A Note on the Diagnosis of Glanders ...	*A. W. Shilston, M.R.C.V.S.* ...	65
Clover and Clover Hay	*Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A.* ...	71
Some Sugarcane Experiments in Travancore	*N. Kunjan Pillai, M.A., B.Sc., Ph.D.* .	79
Notes	... ...	82
Reviews	... ...	91

EDUCATION IN ITS RELATION TO AGRICULTURE.*

BY

BERNARD COVENTRY, C.I.E.,

Agricultural Adviser to the Government of India and Director of the Pusa Agricultural Research Institute

"I am no educator, no teacher; I have made no psychological study of young people from an educational point of view, nor of the different methods of teaching suited to different ages, no statistical investigation of the influence of particular curricula in training the mind or furnishing it with useful information. I have, in short, neither made contributions to the science of education nor practised the art ....I can speak only as a member of the general public not as an expert................ not that I regard the view of the general public as unimportant................ The general public must, as all will admit, decide what is to be spent on education or, more strictly, on schools and colleges and professional educators, out of both public and private income it is for them to decide on its relation to other social and family needs. But the concern of the public with education is not merely financial and administrative. It is more intimate than that. For education is not a subject like physics or chemistry on which only an expert has a right to an independent view. There are, no doubt, aspects of it of which only the expert can properly judge, there are experiments in it which only the expert can advantageously try, and there are, of course, departments of it in which the opinion of the expert is indispensable. But without depreciating either the science and art of education, it is clear that when we take education in its widest sense it concerns everybody and almost everybody is bound to have views about it."

---

* A paper read at the Third Indian Science Congress, Lucknow, 1916.

These words were spoken by no less a person than Mrs. Henry Sidgwick in her address as President of the Section on Educational Science at the recent meeting of the British Association at Manchester.

I feel like Mrs. Sidgwick that I am "no educator and no teacher" and that an apology or at least an explanation is required from me for troubling you to-day in a subject on which I am not an expert. But when we have it on such an authority as Mrs. Sidgwick that education "concerns everybody and almost everybody is bound to have views about it" I feel I have a measure of sanction for imposing my views upon you. I do not propose, however, to make full use of this sanction and tell you all I think about education, but I propose to restrict my remarks to education in its relation to agriculture and further with the exception of an introductory statement dealing with a few facts, I do not propose to say much on the education of youth, but of that of the adult. You will probably all admit that this is quite a novel and peculiar way of dealing with the question of education, but I trust you will find it none the less interesting and instructive. I should like to say before I go any further that I claim no credit for the ideas I shall place before you. They all come from America and, like every thing that comes from that wonderful country, they are exceedingly "cute" and practical and in my opinion are eminently applicable to India.

The population of British India comprises over 255 million souls. Of this vast multitude 80 per cent. or over 200 millions, that is to say, 4 in every 5 are dependent on agriculture. Any educational system therefore which does not take into consideration the relationship it should bear to agriculture is likely to be at a disadvantage. It is on the importance of this aspect of the educational problem I intend to address my remarks. Now out of the whole population, 7½ millions or about 3 per cent. are scholars, though 15 per cent. or 36 millions are of the school-going age. Thus only 20 per cent. of those of the school-going age receive any education at all. Of these 7½ million scholars, about 1 million proceed to secondary education and about 40,000 reach a University career.

In judging of these figures in relation to the agricultural industry it should be borne in mind that the percentage of scholars is much higher in the urban than in the rural areas and also that a very large number of rural scholars never get more than a mere smattering of the most elementary education; so that educational efficiency in rural areas is very much lower than the official returns of general education would indicate. I may appropriately refer here to a small brochure entitled " A Policy of Rural Education " by Mr. S. H. Fremantle[1], the Collector of Allahabad, which has quite recently been published and which is well worthy of perusal. He complains how both in urban and rural schools education is too literary and how primary schools are worked for the benefit of that small section which can afford a secondary education and not in the interests of the overwhelming majority of agriculturists, most of whom abandon their studies after a few months. I think Mr. Fremantle is right. It means that very few indeed of the agricultural population get any education at all, and that, as a class, it can be put down as almost illiterate. The authorities have not been ignorant of these facts, and it is not from want of trying to improve matters that things are at such a low ebb. Much has been done in recent years to improve our system of education, especially in its relation to agriculture and the subject may be said to have received an unwonted measure of attention. In 1901 an important conference was held at Simla presided over by Lord Curzon which led to a complete overhauling of the existing educational machinery. A policy of reform was then started, the vitalizing influence of which is felt to this day. A department of education was created with a member of council in charge. Money grants were increased and they have still further increased, as a result of keen interest taken by the present Viceroy Lord Hardinge who has made education a special object of his attention. Thus the total expenditure which in 1901 was 4 crores, to-day is over 10 crores. The number of pupils in 1901 was 3¾ millions, to-day it is 7½ millions. Interest has been stimulated in every quarter and expansion is noticeable in every branch.

---

[1] " A Policy of Rural Education " by S. H. Fremantle, C.I.E. Newman, Calcutta.

Agricultural and rural education have had quite a fair share of attention, and the need which exists for connecting the teaching of the schools with our chief industry has been and still is fully recognized. I therefore do not complain of want of endeavour. But it cannot be said that these efforts have been crowned with the success one would have wished. But if we have to admit failure, whether complete or partial, we have gained considerably by the discussions which have resulted and by the light which has been thrown on the difficulties inherent in the problem.

The occasion when agricultural education first seriously engaged the attention of Government and the people was in 1904, when the policy for improving the agricultural industry was started by Lord Curzon. At first it was the intention to restrict efforts to improving the industry itself, but later, influenced no doubt by the examples of advanced schemes abroad, the Government elaborated a policy under which not only research and experiment, but agricultural education proper, formed an important and integral part. Large sums of money were devoted to the erection of agricultural colleges in nearly all the Provinces. Syllabuses were prepared by the Board of Agriculture and the Colleges were empowered to grant a diploma of Licentiate of Agriculture. At first signs of success were not wanting. Candidates freely offered themselves for admission and there was found no difficulty in filling the colleges. However, as time rolled on, a decline in admissions became perceptible until the year 1913 when, in some colleges, the position became acute and the matter was brought up for consideration before the Board of Agriculture. The proceedings of the Board in that year indicate the general failure of the schemes drawn up in 1906 and 1908, and we find it expressed that the courses were found not to be suited to the class of students for which the colleges were intended, that the demand and utility for the course is obscured by its being made a road to a degree, that college graduates engaged on the subordinate staff of the Agricultural Department, with very few exceptions, failed to show any power to develop any original line, that intelligent inquisitiveness and power of independent thought was lacking, that the course engendered too much cram and too little power of application, and so forth. What was the root cause of this failure would appear to be explained in one of the resolutions which stated "that the general standard in the Matriculation or University Entrance Examination does not provide a sufficient basis to enable a student to take full advantage of the higher instruction obtainable in the existing agricultural colleges in India" and the Board recommended that a general higher education is necessary in all students admitted to such a course. In other words, it would appear that the standard of general education in the country was too low to afford suitable material with which to man colleges of such an advanced type as those which had been set up by the Agricultural Department. In fact the colleges as educational centres were ahead of the times—primary and secondary education was too backward. Consequently the Board suggested a compromise by lowering the standard of the college curriculum to meet existing conditions and expressed its approval of a two years' preliminary practical course, which had been prepared for the agricultural college at Coimbatore as an introduction to the more advanced course. Many of the colleges have since adopted this, with the result that admissions have considerably increased. While we may expect that the Department will benefit by an increase of recruits for filling its subordinate posts, it has yet to be seen how far the education of the cultivators will be influenced by the change. My own view is that these colleges as instruments for education will not accomplish very much, for the simple reason that they are ahead of the times and that there can be no real demand on the part of the youth of the country for an advanced agricultural course until considerable progress has been made in primary and secondary education and in the improvement of agricultural methods. Not until the industry is more highly developed and the standard of living has been raised, will there arise a demand for higher education amongst the agricultural classes.

The creation of agricultural colleges, however, is by no means the only effort that has been made to improve the education of our agricultural youth. Agricultural schools under the supervision of the Agricultural Department have been started in some provinces which were commended by the Board. They give considerable promise of success and, in my belief, deserve every encouragement. Also, there have been attempts in all provinces to set up a system of rural education by imparting instruction based upon the agricultural surroundings of the children, and endeavours have been made to use nature study as a means to that end. But so far the results, we must admit, have been of a microscopic character.

But there is a form of education which is not included in those I have mentioned and is unknown in India. It is a form of education which has been adopted in certain parts of America and which has of late attracted a considerable amount of attention. It is in my humble opinion applicable to the conditions existing in India and offers opportunities in which officers of the Agricultural and Educational Departments could profitably combine to make the problem of education of the masses easier and more efficient. I will give a brief description.

In America general education is carried on chiefly by the Government by whom large sums of money are yearly allotted to the cause of education, but privately supported colleges are abundant and both these and Government schools are largely assisted by private benefactions, the most important of which are controlled by a private body known as the General Education Board.

Ten years ago great interest had arisen in the upraising of the Southern States whose industrial and educational conditions had fallen very much behind those of the Northern States. Conditions in the Southern States resemble in many particulars those which obtain in rural India. About 80 per cent. of the population is agricultural, depending for its livelihood almost entirely on the produce of the soil. There was great backwardness in both educational and industrial progress. Unfavourable economic conditions existed which were mainly the result of rural poverty. While the average annual earnings of agriculturists in the Northern States were more than 1,000 dollars, those in the Southern States were as low as 150 dollars. Under the auspices of the General Education Board an enquiry was set on foot to study the educational conditions in the Southern States and to devise the ways and means for improving them. The very practical way in which the enquiry was conducted is characteristic of the American people. Surveys were planned State by State. Conferences were held. Monographs were prepared, dealing with the various points on the organization of education. The conclusions which resulted from this enquiry are peculiar. To quote from the Report, it "convinced the Board that no fund, however large, could, by direct gifts, contribute a system of public schools; that even if it were possible to develop a system of public schools by private gifts, it would be a positive disservice. . . . . . . The public school must represent community ideals, community initiative, and community support, even to the point of sacrifice." The Board therefore resolved that assistance should be given not by foisting upon the Southern States a programme of education from outside, but by aiding them and co-operating with them in educating themselves. When, however, it proceeded to apply these principles it was faced with the following initial difficulties. They found the people had not enough money, "that adequate development could not take place until the available resources of the people were greatly enlarged. School systems could not be given to them, and they were not prosperous enough to support them." "Salaries were too low to support a teaching profession.. ....Competent professional training could not exist; satisfactory equipment could not be provided." These conditions were primarily the result of rural poverty. The great bulk of the people was not earning enough to provide good schools and the prime need was money. The Board therefore came to the conclusion that it could render no substantial educational service until the farmers could provide themselves with larger incomes, and consequently they resolved that it was necessary first to improve the agriculture of the Southern States. Now mark what followed. The Board was first advised to address itself to the rising generation and to support the teaching of agriculture in the common schools. But after thoughtful consideration this plan was rejected. They found that in the absence of trained teachers, the effort was impracticable; moreover, there were no funds with which to pay such teachers, and the instruction itself would not materially contribute to its own support. Finally, it was impossible to force intelligent agricultural instruction upon schools whose patrons were not themselves alive to the deficiencies of their own agricultural methods. Until the public was convinced of the feasibility of superior and more productive methods, the public schools could not be reconstructed; once the public was convinced and by reason thereof better able to stand the increased cost, the schools would naturally and inevitably re-adjust themselves.

"It was therefore deliberately decided to undertake the agricultural education not of the future farmer, but of the present farmer, on the theory that, if he could be substantially helped, he would gladly support better schools in more and more liberal fashion." The Board, therefore, set about an extensive enquiry as to the best means of conveying to the average working farmer of the South, in his manhood, the most efficient known methods of intelligent farming. As a result of this enquiry a movement known as the Co-operative Farm Demonstration was set up. A year was spent in discovering the most effective methods of teaching improved agricultural methods to adult farmers. Dr. Seaman Knapp of the United States, Department of Agriculture was engaged to show farmers how to improve their agricultural methods and raise the standard of their industry. It was not long before successful results were obtained. Under improved treatment it may be roughly stated that the crop yields were doubled. Thus in 1909 the average yield in pounds of seed cotton was 503·6 per acre: on demonstration farms the average was 906·1 pounds; in 1910 the figures were 512·1 and 858·9 respectively; in 1911, 624·6 and 1081·8; and in 1912, 579·6 and 1054·8.

In the growing of corn similar results were obtained. In 1909 the ordinary average yield was 16·7 bushels per acre, while on the demonstration farms it was 31·7 bushels per acre. In 1910, 19·3 and 35·3, in 1911, 15·8 and 33·2 and in 1912, 19·6 and 35·4. It is further stated that the poorer the season, the more clearly did the demonstration methods prove their superiority. The work was also studied from the standpoint of the farmer's financial profit. "In Alabama, for example, in 1912, the average yield of lint cotton was 173 pounds per acre; but demonstration acres averaged 428·3 pounds. Demonstration methods, therefore, netted the farmer 255·3 pounds per acre. At the average price of 65 dollars a bale for lint and seed, the farmer made an extra 33 dollars per acre: as there were 8,221 acres under cultivation on the demonstration methods, the total gain was 271,000 dollars. In the same year 7,402 acres were under cultivation in demonstration corn. Demonstration acres averaged 26·9 bushels more per acre than the general average for the State. The demonstration farmers of the State pocketed 139,379·66 in consequence." This was of course in one State alone. These methods have not been restricted to cotton and corn, but have been applied to a very large number of crops and the propaganda is not limited to cultural methods, but is applied equally to the improvement in farm equipment, more comfortable houses, better barns, stronger teams, better implements and cleaner and healthier surroundings. Hence it is claimed that the beneficent results of this work are not limited to financial profit and cannot entirely be measured by money. Characteristic examples of the relief which the new system brought are cited, but one example will suffice. In Mississippi 5 years ago the value of a certain farmer's produce was one dollar per acre and he was 800 dollars in debt. In 1909 his entire farm was worked under the Government method. He averaged 1,100 lb. of cotton against his neighbour's 300 to 400 lb. He made besides 500 bushels of corn and from one special demonstration acre realized 152 barrels of high class seed which he sold for 300 dollars. His debts are now paid and he has cash in the bank. So much for the education of the adult farmer. We now come to the effect this movement has had on the education of youth. We are told that the initiation of demonstration work and the application of the principle of co-operation has resulted in the disappearance of the disorganization characteristic of rural life. Colleges of agriculture, farmers' institutes, agricultural high schools, " Boys' Corn Clubs, " " Girls' Canning and Poultry Clubs " and the like have been brought into existence where practically none of these things existed before, and that the social and educational awakening of the rural South is recognized as being a bye-product of the demonstration movement. Statistics show that the provision for schools has steadily increased. Thus the expenditure for public elementary and secondary schools in North Carolina which was 1,091,226 dollars in 1901, is 4,300,000 in 1913. In South Carolina the expenditure which was 961,897 dollars in 1901 is 2,609,766 in 1913, Arkansas 1,369,809 and 4,279,478, and so forth. These instances give but meagre examples of the important results achieved by the demonstration movement. For greater detail I must refer you to the Report[1] itself.

I think you will agree with me that the educational policy I have described is novel and peculiar. When I say novel, I do not mean that demonstration work has not been used before among farmers and cultivators. We all know that it has, but it is novel in the sense, that never before, so far as I am aware, has demonstration been used in any country as a force and weapon for education so as to make it a condition precedent to the education of youth. It is a new experiment but a new experiment of a remarkable kind. The results indicate that it is no use to try and educate youth if you do not first secure the welfare of the community to which it belongs and that therefore the development of resources should precede education in order of time. What the American General Board of Education says to the farmer in the Southern States is – You are too poor to supply your sons with education; we could assist you, but we do not consider it proper to do so, unless you yourselves contribute. As you cannot do this, we will assist you to increase your earnings so that you will be in a position to provide yourself with schools. When you have done this we will assist you further. We consider that it would be wrong for us to directly educate the rising generation, if you are not able to participate; in fact we believe that it would be a positive disservice for us to do so. Your schools should be started by yourselves, they should represent community ideals, community initiative and community support even to the point of sacrifice.

---

[1] *General Education Board, An Account of Its Activities*, 1902—1914. 61, Broadway, New York.

We have seen how the experiment has succeeded. Might we not with advantage apply the same principles to India? Might we not invite the co-operation of the Agricultural Department in a general scheme and policy of education? Is there any likelihood of success without this? Can we hope to give the youth of this country an adequate educational service unless we go to the root of things, like the Americans have done, and enlist and increase the activities of the Agricultural Department in enlarging the resources of the cultivator and thus build our educational system on the increased prosperity of the agricultural classes? These are the questions I desire to offer for consideration. India is in no better position than the Southern States were 10 years ago. Indeed I think we may safely assert it is in a far worse position. The average earnings of individuals in the Southern States at that time were 150 dollars. In India, according to some authorities, under the most optimistic calculations, they are as low as Rs. 30 per head. You must agree this gives little or no scope for self-help. It therefore seems to me plain that under present conditions we cannot expect the country to supply itself with the means for an advanced system of education. Nor can Government be expected to do so, for Government's resources are limited and depend upon taxation and that in turn depends upon the ability of the people to be taxed. All Government can do is merely to touch the fringe of the problem and supply a modicum of education; it cannot afford to do more. Mr. Fremantle very well describes the situation when he says: "We should surely pause to consider whether the time is ripe for the introduction of a system of general primary education into rural areas. It is a question whether we are not beginning at the wrong end and whether primary education can make any real advance before there is a substantial improvement in economic conditions." These are words which the devotees at the shrine of the policy of free education for the masses might with advantage ponder.

The question then is whether we can, in any way, make the principles which have been so successfully applied in America, applicable to India. My belief is that we can. We have practically the same conditions here as obtained in the Southern States 10 years ago. If anything as I have shown they are a good deal worse. But this is no argument against their adoption. Rather the reverse, for the lower the degree of prosperity, the greater is the need for increasing it. Already in the Provinces a great deal has been done by the Agricultural Department in the way of demonstration of the character described and utilized by the American Board of Education. But it does not go far enough. It, however, forms a nucleus on which to expand and might well be used as a beginning. The work is on the right lines. But we require to do more. We want more men, more money, wider organization, but above all, we require the recognition amongst all classes that in this work lies the germ of future progress. This is a point which is not generally recognized, or, if so, it is certainly not acted upon. While the money spent to-day on education is over 10 crores of rupees, that on agricultural development is only 50 lakhs. That shows that we have not yet got to view these two important problems in their right perspective, and do not fully realize the important relation which agriculture bears to education. Many think that the development of agriculture depends on education, and we gave effect to that view when we started our agricultural colleges. But would it not seem that the truth lies in the opposite direction and that in a backward country like India the advance of education is really dependent on the development of agriculture, and that the best form of education you can give to the rural classes under existing circumstances is demonstration in improved agricultural methods? It was found to be so in the Southern States of America and we have no reason to suppose it is otherwise in India. To carry out the idea it is not necessary to bring our present educational policy to an end. I would not propose anything so revolutionary. Government must, as I have already explained, supply a modicum of literary teaching and this must continue, but it would be an immense improvement if the Agricultural Department were called in to co-operate and demonstration were given a large share in the general scheme of education.

We could not be expected at first to progress with the same degree of rapidity as in America, because we have to do a large amount of research and experiment before we can demonstrate improved methods on a large scale. In America the advanced stage in the agricultural development of the Northern States supplied ready at hand the stock-in-trade required for at once setting in motion the demonstration movement in the backward Southern States. We are not so forward. Still we have achieved enough with our small band of workers to show that the same kind of work can be done out here and that all we require is expansion. Given the means for this (and who will say it would be a bad investment ?) and a recognition of demonstration as an integral part of a general scheme of education, and I feel sure we shall, by such a policy, lay the best and securest foundations for the advancement of education as well as of the prosperity of the people.

THE SAVING OF IRRIGATION WATER IN WHEAT GROWING.

BY

A. HOWARD, C.I.E., M.A.,

Imperial Economic Botanist,

AND

GABRIELLE L. C. HOWARD, M.A.,

Second Imperial Economic Botanist.

ONE of the main directions in which Indian agriculture can be improved is in the proper use of irrigation water. Overwatering is the rule throughout the Continent, particularly on the alluvium of the Indo-Gangetic plain and in many of the deltaic areas of Peninsular India. Among the many evil consequences of over-irrigation is the development of a superficial root-system, with the consequence that many of the irrigated crops are particularly liable to drought and can only be ripened by the use of enormous quantities of water. Even in arid tracts like Baluchistan, where water is exceedingly scarce and land abundant, similar wasteful practices are in vogue and but little real use is made of the present supplies or of the rainfall which, in this region, though small, is particularly well distributed. With the object of drawing attention to these shortcomings, the water-saving experiments described in this paper, have been carried out. The opportunity has been taken of stating very briefly the main principles on which the right use of irrigation water depends.

I. THE AGRICULTURAL FACTORS IN THE QUETTA VALLEY.

The general agricultural conditions in the Quetta valley resemble, to a considerable extent, those of large areas of Central Asia and are markedly different from those of India. The valley is situated at an elevation of about 5,500 feet above the sea and is surrounded by high mountains. There is a gentle slope from the sides to the centre and the main drainage line is westward.

Soil. The soil varies from brown to black in colour and resembles the alluvium of the Indus valley in general appearance and texture. It is a loess deposit, apparently formed by accumulations of wind-blown dust, sometimes mixed with alluvium. With such a geological history and in a climate of great aridity, there have been no opportunities for the accumulation of organic matter. It is not surprising therefore to find that stable manure and green-manuring lead to an immediate improvement in production. Most of the soil of the cultivated areas does not possess a great range in the size of the particles and behaves on wetting very much like the Gangetic alluvium. Flooding destroys the porosity and the surface runs together easily. Under the dry, hot winds which are frequent at Quetta, irrigated land sets on the surface into a cement-like mass, which cracks in all directions and rapidly loses its moisture. There is a great response to aerating agencies such as heavy dressings of stable manure, the growth of a lucerne crop or green-manuring with *shaftal (Trifolium resupinatum).*

Rainfall. The total rainfall is low, about 10·5 inches a year. Most of the precipitation takes place during the winter months, November to March, often in the form of snow. The shallow, cold-weather depressions, which form over Persia and move down into North-West India, often pass over the Quetta valley, and, in doing so, deposit a portion of their moisture. It is to this cause that the winter rainfall in this tract is principally due. The valley is outside the usual area of the Indian monsoon, but it sometimes happens that the storms which cross the continent from the Bay of Bengal, after depositing most of their moisture in Hindustan proper, break up among the valleys of Baluchistan. These increase the humidity of the air and give rise to showers of rain during the months of July and August, but the total quantity received is very small.

Besides the winter rain, there are three chief sources of water for agricultural purposes—*karezes*, artesian bores and subsoil water. The usual method of irrigation is by means of the *karez*. This is an underground ditch on sloping land, which collects the subterranean water near the hills and discharges it on to the surface. It is really an adit with a slight slope, driven into a fan talus with a much greater slope of 300 to 600 feet per mile. The land below the opening of the *karez* is watered by gravitation. The artesian bores as a rule are only about 100 to 200 feet deep and are of from three to four inches in diameter. The water comes from underground streams so that this method of supplementing the rainfall is largely a matter of chance. The distance to the water-level in the wells varies a great deal. In the Civil Station at Quetta it is often less than 10 feet, but on the higher land outside it varies from 20 to 30 feet. Little use is made of this water at present for irrigation purposes on account of the expense and trouble of lifting it. There is little doubt, however, that in certain localities, this groundwater is made use of by trees.

Temperature. There is a well-marked winter at Quetta and, from November to March, the general temperature is low. The summer months June, July and August are hot and, during this period, the minimum temperature is high. The mean varies from 40° in January to 78° in July. The feature, however, of the climate is the great daily range of temperature and the fact that during the winter there is a good deal of air movement. The diurnal range varies from 21°·8 in January to 32°·7 in November.

Humidity. Except when the south winds blow in July and August or after rain, the humidity of the air is low, much lower than in many parts of the plains of India. The drying effect of the air is further aggravated by much air movement, often from the west. Evaporation is therefore rapid so that in fruit and vegetable growing, devices for checking the effects of dry winds are necessary. Mud walls, wind breaks of growing trees and cover crops, which shade the ground, can be used for this purpose.

II. THE PRESENT METHODS OF GROWING WHEAT.

The wheat crop of the Quetta valley is produced in two very distinct ways—under irrigation and as a dry crop. In both cases, the land is fallowed at least during the summer months preceding sowing. The feature of the irrigated wheat growing area near Quetta is the large amount of fallow land and the concentration of the available irrigation water on to a comparatively small area. Land is abundant but water is scarce. Where manure can be obtained, as in the region surrounding the Cantonments, it is freely applied for the production of this crop.

Irrigated wheat. During the early part of the year a certain amount of rough cultivation is given to the fields selected for wheat. When Canopus appears in September, the preliminary watering is given and, when the land is dry enough, the seed is broadcasted on the surface, the land cross-ploughed and then levelled with the beam. After 40 days, the first irrigation is applied followed by the second at the end of December. Watering is stopped during the months of January and February and the third irrigation is given at the end of February. There is then a cessation while the crop is shooting and the fourth application takes place about the middle of April followed by at least two more at intervals of about fifteen days till the grain has formed. Including the preliminary irrigation before sowing, at least seven waterings are given for irrigated wheat and, to obtain the highest yield, the land is always heavily manured.

The most interesting and significant features of the crop are the slow rate of development about the time the ears appear and the manner in which ripening takes place. The well-known changes in colour of the ears during ripening do not occur at Quetta. The ears dry up slowly from the tips rather than ripen and the full colour of the chaff is not developed. There appears to be a factor which limits the rapid ripening of the crop and there is some evidence for supposing that this is want of air in the soil caused by the destruction of the tilth by frequent watering.[1] Towards the end of the season, the temperature rises rapidly and the hot, dry, westerly winds set in.

---

[1] Soil Ventilation, *Bulletin 52, Agricultural Research Institute, Pusa,* 1915.

Dry wheat. For the unirrigated wheat, the fields (*bands*) near Quetta are embanked. These are filled with rain or flood-water in the summer or winter, after which they are ploughed and the seed sown. In other parts of the District, such as Pishin and Toba, the dry wheat tracts are seldom embanked and sowing takes place only when the rain and snowfall have given sufficient moisture for the purpose. Everywhere the dry crop is dependent on good rains in the winter and spring and sowing usually takes place only after the fields have received sufficient moisture. Dry wheat in the Quetta valley is a precarious crop and the yield rarely exceeds five maunds of grain to the acre. In parts of the Quetta tahsil and in the Alizai circle of Pishin, a system, known as *garar*, is followed in dry crop lands, the soil being prepared in September and October and the seed sown without moisture after which it is left till the winter rains cause it to germinate.

Yield. The results of numerous crop cutting experiments in the District are summed up in the Quetta-Pishin *Gazetteer* (p. 102) as follows:—

"In Quetta, 75 expeiiments were made in 1895-6 and the outturn of wheat per acre in irrigated land was found to be 15½ maunds, the highest being 17½ maunds in the Kasi circle and the lowest 14 maunds in the Baleli and Durrani circles. Mr. J. A. Crawford, in commenting on the items, remarked that the results of crop experiments were notoriously apt to be high. Further experiments, made in 1903-4, however, showed still higher returns, the average in irrigated and manured land being 24 maunds 6⅔ seers, and in irrigated land, not manured, 13½ maunds. In other parts the average has been found to be as under:—

	Pishin Mds.	Shorarud Mds.	Chaman Mds.
Land irrigated and manured	25	15	15
Irrigated land not manured	16	12	10
Dry land	5	5	3

The average yield per acre in land under the Government irrigation works in Pishin, which are not generally manured, has been as follows:—

		Mds.	Srs.	Ch.
Shebo Canal, 1892-3 to 1903-4	...	5	32	14
Khushdil Khan, 1892-3 to 1903-4	...	7	34	9

In such a manner is the wheat crop produced in the Quetta valley at the present time. It will be interesting to examine critically these processes in the light of the principles on which agriculture has progressed in other arid tracts and to ascertain how far they conform to the best irrigational practice.

III. THE PRINCIPLES UNDERLYING WATER SAVING.

In the growth of the wheat crop under conditions where the rainfall is twenty inches or less, experience has shown that, in order to obtain the highest possible yield, the water-conserving methods of dry farming must be employed. Where in such cases the rainfall has to be supplemented by irrigation and the wheat crop has to be grown, partly by means of the natural rainfall and partly by artificial watering, it has been found, both by experience and by experiment, that the best results are obtained by the skilful application of the following five principles:—

1. **The irrigation water available should be spread over the largest possible area.** This rule is based on the fundamental law that, as more water is applied to a field of wheat, there is a regular diminution in the yield per unit of water applied. This will be clear from the recently published Utah results.[1]

TABLE 1.

Yield of wheat with varying quantities of irrigation water.

Inches of irrigation water applied	Bushels of grain to the acre	Pounds of straw to the acre	Pounds of straw for each bushel of grain	Bushels of wheat for each inch of water
5·0	37·81	2,986	79	7·56
7·5	41·54	3,301	75	6·39
10·5	43·53	3,452	79	4·35
15·0	45·71	3,954	87	3·05
25·0	46·46	4,311	93	1·86
35·0	48·55	4,755	98	1·39
50·0	49·38	5,332	108	0·99

---

[1] Widstoe, *Principles of Irrigation Practice*, 1914, p. 250.

The chief point which emerges from these experiments is that when five inches of irrigation water were applied each inch produced 7·56 bushels of wheat. When the water was increased to fifteen inches, each inch yielded only three bushels. When the large quantity of fifty inches was employed, each inch produced less than a single bushel of wheat. Small waterings therefore do far more good per inch of water than large applications. This point is rendered clearer by the results obtained in Utah when 30 inches of water were spread over six acres instead of over one. The total yield of wheat rose rapidly from 47·51 to 226 bushels.

	30 ACRE-INCHES SPREAD OVER				
	1 acre	2 acres	3 acres	4 acres	6 acres
Grain	47·51	91·42	130·59	166·16	226·16 bushels
Straw	4,532	2,908	10,256	13,204	17,916 pounds

These figures clearly indicate that when the quantity of water is limited, as it is in most arid tracts, the least possible amount needed to ripen a wheat crop must be applied to each acre of land. With these facts before us we should expect that the six or seven heavy irrigations applied to a single crop of wheat at Quetta must result in an enormous waste of valuable water.

2. **Heavy waterings reduce the proportion of grain to total crop.** This principle is well known and is confirmed by numberless experiments. With the increase in available water, the length and weight of straw increase far more rapidly than the weight of grain. As straw is much cheaper than wheat, it is clearly of no advantage to use valuable water mainly to increase the yield of straw. This point is brought out in Table 1 above where in the fourth column the rise in the proportion of straw to grain with increasing irrigation is indicated.

3. **The growth period of wheat is increased by heavy watering.** All observers who have carefully studied the wheat crop must have been impressed by this fact. At Quetta, the difference between

the time of ripening of wheat grown with the minimum quantity of water and that raised by the zamindars is at least a month. Late ripening is a great disadvantage in the Quetta valley as towards the end of the season the temperature rises rapidly and this rise is accompanied by hot, dry, westerly winds. Maturation therefore takes place under exceedingly unfavourable conditions as is shown by the fact that the wheat crop does not really ripen and show the usual development of bright chaff colour, but merely dries up to a somewhat uniform dull white. It is not surprising, therefore, that the grain is not well filled and that the feeding value of the *bhusa* is greater than that imported from Sind.

4. **When the water supply is limited, the root development of the wheat crop must be deep.** The first stage in the growth of the wheat plant is largely subterranean and, during this period, root formation goes on rapidly, provided the soil has been well cultivated and contains a sufficient supply of air and moisture. Wheat should not be watered during this stage, as irrigation, by interfering with the air-supply, tends to check the downward development of the roots and to encourage superficial rooting. Such a shallow-rooted crop cannot make the best use of the winter rain and is particularly liable to suffer from drought. The two early waterings of the wheat crop at Quetta are therefore harmful as, after sowing, the roots should be made to grow down deeply into the soil and abstract moisture from the lower levels.

5. **The soil moisture must be preserved as far as possible by a surface mulch of dry soil.** The moisture in the soil, in which a wheat crop is growing, is lost mainly by evaporation from the surface and also by transpiration through the plant. It is obvious that when the water supply is limited, as much water as possible must be passed through the plant and as little as possible lost by evaporation from the surface of the ground. The easiest method of checking this evaporation in the case of wheat is by means of a surface mulch of dry soil, produced and maintained by suitable methods of cultivation. The loose, dry layer of earth on the surface hinders the movement of soil water into the air. The action of the mulch is not difficult to explain. The moisture in the soil occurs as thin

films surrounding the soil particles and, after surface irrigation or rain, these particles run together into a position of close packing so that the water films form a continuous system right through the soil. At the surface they come in contact with the atmosphere. If the air is dry, evaporation of the water takes place at once. When the air is dry and warm and also in rapid motion, as it often is in arid tracts, the evaporation is exceedingly rapid and the irrigated or rain-wet surface rapidly dries. As the water near the surface of the soil passes into the air as vapour, a continuous movement of water takes place from the soil and subsoil to take its place At the same time deep cracks are formed, so that the evaporation soon begins to affect the moisture in the subsoil as well. The result is rapid drying out to a great depth. The dry mulch breaks the contact between the films of water round the particles and the atmosphere and checks evaporation. Its efficiency depends largely on its depth. A three-inch mulch will often reduce the loss by evaporation at least fifty per cent., while a six-inch mulch is much more effective. A mulch, about a foot thick, often prevents evaporation altogether.

In wheat growing, the surface mulch has to be produced while the crop is in the ground and often while the seedlings are small and tender. Deep mulches are therefore out of the question as their formation would destroy the crop. It is found that very effective mulches can be produced in a young wheat crop by an implement known as the lever harrow. This is an ordinary toothed harrow so constructed that the slope of the tines can be altered by a lever. By sloping them backwards, a lever harrow can be drawn over a young crop of wheat without damage to the plants and, at the same time, any surface crusts can be broken up and a mulch of dry earth produced. On soil like the Indo-Gangetic alluvium or that of the Quetta valley, a single cross-cultivation with these harrows will produce a mulch about two inches thick which goes far to preserve the water in the soil. The harrow can be used till the wheat is nearly a foot high. Whenever rain falls, the surface must be harrowed and the dry mulch re-formed. In the Quetta valley, no such implement as a harrow is used by the zamindars and they do not understand the value of surface mulches. In consequence, their dry wheat has to grow and ripen with a surface crust always present and with the soil moisture constantly exposed to free evaporation into the dry atmosphere. There is little wonder that the crop is so stunted and that the yields are so poor.

If, therefore, the methods of growing wheat at Quetta are examined in the light of the best modern practice in arid regions only one conclusion can be drawn. The local practices are wasteful and unscientific in the extreme. Water is thrown away in all directions; there is no effort to conserve the soil moisture and to make the best use of what is, to the wheat crop, a most timely and well-distributed rainfall. All the conditions were therefore exceedingly favourable for the conduct of water-saving experiments and, as soon as the land for the new Experiment Station was acquired, these were set in motion.

IV. EXPERIMENTS IN WATER SAVING AT QUETTA.

The experiments in water saving in wheat growing, conducted at Quetta during the last three years, have been of two kinds. Wheat has been grown on the natural moisture only and also on the rainfall, supplemented by a single irrigation applied to the land before sowing in October. The amount of the rainfall during the period covered by these investigations is indicated in the table below which gives the precipitation at the Civil Hospital, situated quite close to one of the experimental plots.

TABLE II.

Rainfall in inches at Quetta, 1912-1915.

	1912-13	1913-14	1914-15		1912-13	1913-14	1914-15
September	*nil*	*nil*	0·02	April	0·12	0·97	1·96
October	*nil*	0·19	1·87	May	*nil*	0·55	*nil*
November	0·03	0·95	1·91	June	0·08	0·46	*nil*
December	1·50	0·90	1·16	July	0·19	0·76	*nil*
January	0·69	1·70	0·43	August	0·12	*nil*	*nil*
February	3·73	3·29	0·45				
March	2·69	1·20	1·44	TOTAL	9·15	10·97	9·24

It will be seen that practically all the rainfall is received between October and May during a period when the wheat crop can make use of it. It is unusually well distributed and can be entirely absorbed into the ground, provided the surface is kept in the proper condition to receive it. This distribution of the rainfall is an ideal one from the point of view of the wheat crop, and it is a great pity that so little use is made by the cultivators of the gifts of Providence and that they do not attempt to conserve the moisture by means of a surface mulch of dry soil.

Wheat grown on natural moisture only.

In the season 1913-1914, two large plots were sown with wheat on natural moisture only. In both cases, no storm water was embanked on the land before or after sowing as this was impossible on account of the situation of the ground. The only moisture at sowing time was that conserved during the dry, hot summer from the previous winter rains by a surface mulch of dry soil, some three to four inches in depth.

The first plot, three acres in area, was situated at the new Experiment Station about two and a half miles from Quetta. The land was high-lying and freely exposed to the hot, drying winds. It was unmanured and so situated on a ridge that it received its own rainfall only and was not subjected to any surface wash from higher land. The mulch was found to conserve the soil moisture exceedingly well up to the end of June but, during the hot months of July, August, and September, the subsoil dried a great deal and, at sowing time, there was insufficient moisture for even germination and for maintaining the seedlings till the winter rains set in. The result was a very thin crop which gave only 2 maunds 27 seers of grain and 7 maunds 23 seers of *bhusa* per acre.

The second plot was just over half an acre in area and was situated on low-lying land within the Civil Station at Quetta and to the south of the Residency. The land was heavy in texture, the subsoil moisture was somewhat near the surface and the plot was protected from the dry winds by trees and high walls.

The growth was luxuriant but some damage was done by yellow rust (*Puccinia glumarum*) as the wheat came into ear. The yield worked out at 21 maunds 1 seer of wheat and 40 maunds 38 seers of *bhusa* per acre. The conditions were, however, exceptional and there is no considerable area of land in the valley where similar crops can be obtained. In one respect, however, the result is of interest. The land was typical of most of the area on which the Civil Station has been built, and the fact that a yield of over 20 maunds of wheat to the acre was obtained without irrigation at all shows that a great deal more use could be made of the subsoil water than is at present the case. It can readily be understood how easy it is to over-irrigate the land in this tract and to turn the foliage of the peach trees yellow.

The water conservation methods employed in these experiments were the same. In both cases, the crusts formed by rain were broken up by the lever harrow and a mulch of dry soil, about an inch and a half in depth, was left on the surface. After the wheat began to shoot in March, the use of the harrow had to be discontinued with the result that the crop had to ripen with a distinct surface crust formed by the late rains in March, April and May. This led to a considerable loss of valuable moisture during the ripening period.

Wheat grown with a single irrigation.

Two large scale experiments were made at the Experimen Station in 1912-13 and in 1914-15, in which a single irrigation was applied to the land in September prior to sowing in October. When it was observed in 1912 that, in ordinary exposed wheat land, a mulch of dry soil three to four inches in depth was insufficient to conserve the subsoil moisture from one winter to sowing time the following October, it seemed probable that a single irrigation, applied before sowing, might prove effective. This would enable a thorough cultivation of the land to be carried out before putting in the seed and would reinforce the water in the soil and subsoil to such an extent that there would be ample moisture for germination and for rapid root-development before the winter rains were received.

The land was irrigated by surface flooding in the ordinary way and, as soon as the surface was dry enough, it was cultivated by means of the spring-tooth cultivator and immediately levelled with the beam. This operation is of the greatest importance in crop growing in Baluchistan both from the point of view of the saving of water and of the production of a good tilth. Irrigated land dries very quickly, and, unless it is ploughed up at exactly the right moment, large clods are formed which cannot be broken down by the beam. Where the area watered is several acres and the cattle power is limited, it is impossible to deal with all the land at the proper moment with such a slow-working implement as the country plough. The consequence is a great loss of moisture and a poor tilth. What is required is a machine which will rapidly cultivate the surface of a large area and, by the production of a surface mulch, check the rate of evaporation and also help to make a good tilth. This can be done easily and rapidly by the spring-tine cultivator followed by the beam. A pair of cattle with one of these machines will cover at least three acres in a day and, by checking evaporation, enable the land to be ploughed and sown with ease, at the same time producing natural conditions in the soil which lead to the formation of an excellent tilth when the land is ploughed.

After sowing, which was done behind the plough in the ordinary way, the only treatment necessary was the breaking up of surface crusts after rain and snow. This was done by drawing over the crop, by means of two bullocks, a pair of Canadian lever harrows. By sloping the tines backwards these harrows will pass over young wheat without damage and, at the same time, break up thoroughly the crusts formed by rain. The cost of a pair of these harrows, f. o. b., at New York, is 12·90 American dollars (Rs. 40-4-0) and they cover a strip of land 9 feet 8 inches wide. The number of harrowings required naturally varies with the year. For the 1915 crop, the young wheat was harrowed four times. After the crop began to shoot, the use of these harrows had to be discontinued and the crusts formed by the rains of late March and April led to a great deal of loss of moisture. Experiments are in progress to find means of harrowing the wheat up to the time it comes into ear.

The 1915 crop ripened about a month before that of the cultivators and was affected by yellow rust far less than the irrigated wheat. An interesting feature was the full development of the chaff colour which is hardly ever seen in the country crop. The results of the experiments are given in Table III.

TABLE III.

Yield of wheat at Quetta with a single irrigation.

Season	Area in acres	Yield of grain per acre	
		M.	S.
1912-13	3·00	18	30
1914-15	2·85	16	28
	Average	17	29

One maund = 82·27 lb.

The average yield of these large scale experiments was thus 17¾ maunds per acre or four and a quarter maunds above the average yielded by similar unmanured land with six or seven irrigations (p. 18). The real difference between the Experiment Station results and those obtained by the people can best be realized however by comparing the produce in both cases from the same amount of water. The zamindars water one acre seven times and obtain an average of 13½ maunds of grain. The same amount of water spread over seven acres, if used according to the method employed at the Experiment Station, would give 7 times 17¾ or 124¼ maunds of wheat. The difference in favour of the experiments is therefore 110¾ maunds of wheat. If the average irrigated acreage of wheat in the Quetta valley is multiplied by 100, the result would indicate, in maunds of wheat per annum, the present annual waste of water on this crop alone. On every 100 acres of irrigated wheat, the water now lost would produce 10,000 maunds of grain and a large amount of straw of a total value not far short of half a lakh of rupees. All the water now lost could not of course be translated into grain and *bhusa* as the necessary preliminary irrigations could not be done in time with the water supply now available. A large proportion of the loss however could be utilized in wheat growing, while the remainder could be employed for the winter watering of fruit trees and in the production of fodder crops like *shaftal* and lucerne.

It is clear that as far as irrigated wheat growing is concerned, there is an enormous loss of water which might be profitably employed. The skilful use of the lever harrow after rain would also increase the yield of the unirrigated or dry crop wheat. Examined scientifically, the methods now in vogue are wasteful in the extreme, both as regards the precious irrigation water and the winter rain and snow which cost nothing. To enable the zamindar to improve his practice, two new implements are necessary—the spring-tine cultivator[1] costing about thirty rupees and a pair of Canadian lever harrows which cost at New York before the war about forty rupees. With proper care and if the working parts are replaced when worn out, these implements would last ten years at least, so that the annual cost would not be over fifteen rupees. Each cultivator need not purchase these implements for his own use. Two spring-tine cultivators and a pair of lever harrows would suffice for an ordinary village. The cost of using them is, from a zamindar's point of view, negligible as he now has to keep cattle as well as servants to feed and look after these animals. A little gentle exercise for the men and animals in the winter in harrowing the young wheat after rain would do them no great harm. The economics of the suggested improvements in production do not therefore admit of argument. At a small cost, a very material increase in wheat production is possible in the Quetta valley. The increased yields of grain and *bhusa* will directly benefit both the people and Government while the greater production of the neighbourhood is an obvious military advantage.

---

[1] The spring-tine cultivator can be used for many other purposes besides wheat growing, such as cultivating between the rows of trees in fruit gardens, breaking the surface of lucerne fields and sowing crops like maize and *juar*.

One possible objection must be dealt with at this point. It may be urged that results such as those above are only possible under European supervision and that the zamindars could not possibly repeat them. The reply is that the Experiment Station results were obtained by the Indian staff and that all the operations, including sowing, were carried out by the overseer from written directions during our absence from Quetta.

Besides their bearing on the local agriculture, these experiments have some application to Indian conditions where the saving of irrigation water has not, up to the present, received very much attention. There are several tracts in India where a fair wheat crop might easily be raised on a single irrigation applied prior to sowing. In Bundelkhand and other black soil tracts, where the monsoon often ceases early and where there is insufficient moisture in the ground for germination, a preliminary irrigation before sowing would cool[1] the land and also enable a rapidly maturing variety like Pusa 4 to ripen a full crop of wheat. Irrigation after sowing, on heavy black soils, is likely to interfere with the air supply of the crop and to diminish the yield so that some of the various tank projects in the Central Provinces might be designed to irrigate a large area in September and early October once rather than a smaller number of acres several times during the cold weather. Experience will soon prove which of these methods is the one to adopt. In such comparisons, the yield per acre-inch of water must be considered, not the yield per acre.

In some of the alluvial tracts like Oudh and the middle Doab, a single irrigation in early October (provided the moisture is properly conserved) will probably be found to be sufficient for a rapidly maturing wheat variety. After flooding the surface, the land would have to be cultivated as soon as possible with the spring-tine cultivator, followed by the beam so as to check evaporation and to allow of the natural formation of a perfect tilth before ploughing and sowing. After sowing, the lever harrow would have to be used as long as possible so as to conserve the soil moisture and to break up the crusts formed by rain and dew.

---

[1] It is well known that the late rains of September and early October are very beneficial for *rabi* crops. There is considerable evidence for supposing that a large portion of the benefit is due to the cooling effect of this rainfall on the soil. This enables the cold-weather crops to form a deep and vigorous root-system. In years when the rains cease early and the soil is hot at sowing time, it is more than likely that a single irrigation in late September or in early October, besides giving abundant moisture for sowing, would also cool the ground very considerably. The matter is one worthy of extended experiment as it is probable that in this way more use could be made, in several tracts of India, of the water available.

Besides the saving of irrigation water, such a method of wheat growing in India has other advantages. Both the sowing and harvesting periods could be extended. A rapidly growing variety can be sown quite late, while the same variety, sown at the usual time, would ripen considerably earlier than the ordinary crop, thus allowing of an early harvest and so relieving the strain on the cattle and labour available at this period.

INDIAN HEMP FIBRE.

(*Crotalaria juncea.*)

BY

C. D'LIMA.

Of the many Indian products the trade in which has been making steady strides during the last ten years, Hemp, the fibre of *Crotalaria juncea*, is by no means an unimportant one. Roxburgh and the other authors who have followed him have left behind them most valuable literature bearing on the subject, while the officials of the Agricultural Department have by means of Ledgers and other publications issued from time to time added considerably to the richness of the literature already extant. In this article the writer does not claim to make any material addition to the said literature, but aims merely at placing before the Indian Authorities and the European trade certain aspects of the subject from a practical business man's standpoint, and offers a few suggestions which the writer thinks might prove of interest to the trade generally, and which, if carried out, might redound to the advantage of the Indian agriculturists to a very appreciable extent.

To be able to gauge correctly the importance of the export trade in Hemp, one has only to refer to the Trade and Navigation Returns of the Presidency of Bombay, and the appended Statement ought to serve to give one a fair idea not only of the quantity exported from year to year and of the money value such exports represent, but also of the manner in which the trade is distributed among the various foreign markets. It is true that since 1908-1909 there has been a falling off in the quantities exported due more to bad crops in some of the more important hemp-growing districts than any other cause, but, as will be seen from the Statement appended hereto, the decrease in the quantity is compensated for by an increase in prices.

The enormous quantities shown in the Statement do not, however, represent the produce of the Bombay Presidency alone; on the contrary except for a few thousand bales the bulk of these exports is made up of fibre obtained from the Central and United Provinces where it is grown on a considerably larger scale than in the Bombay Presidency, and where the quality of the fibre produced is uniformly superior to that available in the Bombay Presidency, excepting of course the Ratnagiri district which produces a superior and therefore valuable fibre. Whether or not it is possible to extend the cultivation of hemp in the Bombay Presidency and expand the trade in it on a parity with the trade now being done in some of the more important hemp-growing districts in the Central and United Provinces is a question which will be dealt with below.

For any Indian fibre to be able to command a ready sale in the European markets and realize good prices, it is essential that it should be of good length, thin and soft, strong, and above all free from sand and dust; indeed the Factory Regulations in Europe, and in England particularly, are so very strict, where the utilization of dirty fibres is concerned, that European buyers have already taken to steadily rejecting all fibres which contain a large admixture of sand and mud, and it is not unlikely that what little trade there is at present in inferior fibres will disappear altogether before long.

In the light of these observations we shall proceed to discuss the prospects, if any, of fibre prepared in the Bombay Presidency being able to compete successfully with fibre prepared in the Central and United Provinces, for unless it can be established that such competition is possible even to a remote degree, the industry is certainly not worth persisting in, and the agriculturists might as well turn their attention to the raising of some other crop which is likely to prove more lucrative than hemp.

From figures kindly supplied to the writer by the Director of Agriculture, Bombay, in 1907, it appears that the area then sown with hemp was not less than 22,116 acres. Since then the acreage

Quantities and value of Hemp exported f

	1904-1905.		1905-1906.		1906-1907.		
	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Qua C
British Empire.							
United Kingdom	80,906	8,53,935	96,222	10,07,007	80,105	9,32,643	9
Victoria	60	720	83	1,328	..	......	.
Bahrein Islands	...	......	...	...	..	......	.
Other Countries	42	504	5	86	65	920	
Foreign Countries.							
Sweden	...	......	...	.. ..	..	......	.
Norway	..	......	..	......	283	4,252	
Denmark .. .	..	.. ...	. .	......	7	70	
Germany	25,619	2,49,587	31,675	3,34,753	38,019	4,12,640	7
Holland	875	7,500	175	1,500	437	6,569	
Belgium	133,727	13,06,855	120,671	12,01,948	117,779	12,99,909	13
France	8,809	1,03,696	11,821	1,25,725	12,278	1,33,228	1
Spain .	375	7,125	685	8,335	557	6,450	1
Italy	5,224	58,689	1,880	18,772	2,995	38,411	t
Austro-Hungary .	...	... ..	70	840		......	
Asiatic Turkey	..	......	...	......	...	......	.
Muscat Territory and Oman ..	3,258	43,143	2,762	33,567	2,151	31,546	:
Other Native States in Arabia ..	.	......	3	36	...	.....	
Persia	580	7,074	61	822	93	1,128	
Japan	1,001	13,082	914	11,574	519	5,518	..
Italian East Africa . ..	...	.. ...	..	. ..	.	.....	..
Somaliland	...	... ..	...	. ..	87	1,215	
Other East African Ports ..	177	1,771	25	365		......	..
U. S. of America	...	......	...	... ..	.	......	..
U. S. of America (Atlantic Coast)	...	......	...	.. ...	.	... ..	..
Other Countries	41	497	37	572		. ...	..
TOTAL	260,781	26,54,178	267,092	27,52,230	255,375	28,74,499	341
	...	£176,945	...	£183,482		£191,635	..

utilized for hemp cultivation in the various districts has probably undergone a considerable shrinkage, as the quantity of fibre exported is nothing like what it should have been if such a large area as 22,000 acres were under cultivation.

The principal hemp-growing district in the Bombay Presidency at present is the Ratnagiri district, and the fibre produced there which to the trade is familiarly known as "Deoguddy Hemp" always commands a ready sale and invariably realizes a higher price than that obtained for the best descriptions of fibre produced in the Central and United Provinces. Except when owing to long drought the plants are stunted affording fibre so very short as to render it sometimes almost unmerchantable, or when owing to incessant heavy rains during the maturing season and again during the retting season the fibre undergoes a certain amount of deterioration both in colour and strength, "Deoguddy Hemp" possesses all the qualities requisite in a good fibre. It is of fair length, soft, strong and perfectly clean with a fine gloss, and is in request not only in the English markets but it is also eagerly sought for by Continental buyers. So far therefore as this hemp is concerned, agriculturists would be well advised in extending the cultivation, as compared with the prices realized for other Indian fibres those obtained for Deoguddy Hemp are certainly very remunerative.

There are two other grades of hemp produced in the Bombay Presidency which once commanded a fair sale in the European markets but which of recent years have been steadily falling into disfavour, *viz.*, "Salsi" and "Godhra" hemp. "Salsi" as the name implies is hemp grown in the Island of Salsette, and in his valuable treatise on *Crotalaria juncea* Dr. Watt repeatedly refers to the superior quality of this hemp conveying the impression that not very many years ago the Island of Salsette produced a fibre reckoned superior to even the Bengal sunn-hemp. It seems indeed a pity that the cultivation of hemp should have now been altogether discarded in this part of the Presidency, for if it were possible to prepare in Salsette a fibre possessing the merits which have been ascribed to it by certain authors, it should certainly pay the agriculturists to devote greater attention to this industry, the more so and the European buyer alike as they could be exported from other Indian ports.

Of the two provinces referred to above the United Provinces undoubtedly have a larger area under hemp cultivation than the Central Provinces, but save for 12,000 to 15,000 bales which reach Bombay from the Pilibhit, Bareilly, and Moradabad districts, the bulk of the hemp from the United Provinces is railed to Calcutta and thence shipped to Europe. *Apropos* of the hemp produced in these Provinces, it has been a moot point whether hemp (*Crotalaria juncea*) grown in India is of only one kind or whether there are several distinct varieties of it, or whether the difference in the fibres is due merely to the influence of soil and climate, and the different methods adopted in the preparation of the fibres. Royle seems to have been of the opinion that there were more than one fibre-yielding species of *Crotalaria*, while Roxburgh and others were inclined to the idea that only one species of Sunn-Hemp was cultivated in India. In the *Memoirs of the Department of Agriculture in India, Botanical Series*, Vol. III, No. 3, Mr. and Mrs. Howard of Pusa provide a valuable contribution on the subject, and in the light of experiments personally conducted by them they establish the existence of two cultivated varieties of Sunn-Hemp in India.

This digression has been rendered necessary because of the fact that the United Provinces produce two fibres characteristically distinct, the one resembling the Jubbulpore hemp, the other a white "towy" kind popularly known to the trade as "Sunn," and there is at least one place in the Fatehpur district where seeds sown at the same time and the plants treated in all respects alike give two distinct varieties of fibre, a result which can only be ascribed to the plants being two distinct forms of *Crotalaria.* As the European trade treats these two forms of fibre on a different level, it is perhaps as well to discuss their merits and demerits separately. "Pilibhit Hemp"—this is how the hemp from the United Provinces is known as shipped at present from Bombay to European ports. In many cases of course the description is merely a misnomer, as the fibre supplied under this denomination does not always comprise the production of the Pilibhit District only. "Pilibhit" hemp is reckoned by the European trade among the cheaper grades of Indian fibres, which from the point of view of the agriculturists in this District is most unfortunate, in that it prevents their obtaining the real value of the fibre. The area under hemp cultivation in the Pilibhit district is over 6,000 acres. Of recent years there has been a marked improvement in the preparation of the fibre, and if care is taken by the agriculturists to maintain this improvement scrupulously avoiding all admixture of dirt, it should be possible to place on the market a fibre by no means inferior to some of the higher priced descriptions of hemp from the Central Provinces. Unfortunately there is a marked tendency, if not on the part of some of the agriculturists themselves, at any rate on the part of those who handle the hemp after it has left the agriculturists' hands, to "fake" it with a liberal admixture of the more inferior hemp from Bareilly and Moradabad districts, with the inevitable result that European buyers not knowing the real quality and worth of the hemp actually produced in the Pilibhit district will only pay a low price for it. To enable one to judge approximately to what extent the "faking" process might be resorted to, suffice it to say that Bareilly district grows as much hemp as Pilibhit and as the two districts closely adjoin each other, the transporting of hemp from the former district to the latter is a very easy matter. So long therefore as the unscrupulous methods referred to are indulged in, the agriculturists of Pilibhit must be content to earn considerably lower prices than they might have obtained if the genuine Pilibhit hemp had been placed on the European markets.

There can be hardly any comparison between Bareilly and Moradabad hemp with Pilibhit hemp. The former is shorter in length, rougher, and above all very much dirtier, and were it sold on its own merits instead of it being used for the purpose above referred to, it would realize very poor prices. That even in the case of this hemp the quality could be improved there is no doubt, but there is no incentive to any attempt being made in this direction, and there never will be, so long as the agriculturists from these districts can be sure of getting the same price for their inferior fibre as is realized for the superior one from Pilibhit.

And this brings us to the other variety of hemp produced in the United Provinces which has hitherto not been shipped through Bombay but which could be shipped as advantageously through this port as through Calcutta, specially the hemp produced in the Fatehpur, Banda, Allahabad, Jaunpur, Oudh, and Partabgarh districts. These districts chiefly produce what is known to the European trade as " Sunn " Hemp and which is shipped as " Benares " and " Allahabad," the former representing the better and the latter the inferior grades.

Although this class of hemp does not as a rule contain much admixture of mud or sand it is nevertheless very cumbrous to handle as it contains a large proportion of pieces of stems entangled in the fibre. This defect is accounted for by the fact that the retted stems after being partially washed are taken out of the water and exposed to the sun to dry for some hours and are then *beaten* to separate the fibre. This method not only results in the fibres getting entangled but there is always a large proportion of pieces of stems adhering to the fibre, and the process of partially heckling the hemp which the exporter has to resort to to free the fibre of the admixture not only results in a very serious shrinkage in weight but also entails very heavy expense. It is strange that this method of preparing the fibre should be resorted to in some of the districts while in others the peeling process is most in vogue. By the latter process it would be possible to obtain a more lengthy and cleaner and therefore a more valuable fibre than the one available at present.

Sunn-Hemp (*Crotalaria juncea*) is grown in most of the districts of the Central Provinces but chiefly in the Jubbulpore, Mandla, Seoni and Betul districts, and the fibre from these parts as supplied to the European trade is known as " Jubbulpore," " Seoni," and " Itarsi " respectively. Genuine Itarsi hemp is the produce of the Betul district. It is the best quality of fibre produced in the Central Provinces and commands the highest price. The season's turnover as well as the quality of the fibre is, however, very often affected by unseasonable weather conditions in which case it is replaced by hemp from the Chhindwara or Seoni districts. The only fibre which approaches nearest to genuine Itarsi is that produced in Chhindwara, but as the sales of what is known as "Itarsi" grade invariably exceed the supply, other descriptions are very often tendered under this name. Hemp produced in Seoni itself while slightly inferior to Betul and Chhindwara hemp is superior to that produced in other *tahsils* of the same district such as Bhoma, Gunsoor, Palari, and Keolaree, although all these fibres are tendered by the Indian seller and accepted by the European buyer as "Seoni." Mandla hemp is not unlike Jubbulpore in quality, while as regards the Jubbulpore district, Sihora and Silondi produce a superior fibre to that prepared in Jubbulpore and the suburbs. The Narsingpur district (Kareli and Gadarwara) produces the lowest quality of hemp in the Central Provinces and this is often used for the same purpose in Jubbulpore as Bareilly and Moradabad hemp is in Pilibhit. "Itarsi," "Seoni," and "Jubbulpore" hemp is always in demand both in England and the Continent of Europe, and unless the quality of the fibre should show a marked deterioration these grades would realize uniformly high prices.

Besides the various grades of hemp enumerated above, the only other fibre which reaches the Bombay market is that from the Gulburga district in the Nizam's Dominions. It is well prepared and in normal seasons the quality of the fibre is very satisfactory.

Bombay receives no hemp from the Punjab or the Gwalior State, while the whole of the hemp produced in the Madras Presidency is shipped direct to Europe from the Madras coast ports.

In the Philippines, the Government has thought it fit to introduce legislation standardizing the grading of hemp produced in the country. In India it would be impossible to enforce any such legislation, nor could the Government undertake it seeing that in the case of more important products such as cotton, etc., there is no state control over the standardization of the quality. When, however, one considers the numerous complaints which have reached India from time to time regarding the poor classification of Indian hemp, and also bears in mind the fact that the prices hitherto realized by the agriculturists in some of the hemp-growing districts have not been quite as remunerative as they might have been, the question which naturally forces itself upon one is whether even without any direct state control it might not be possible to devise ways and means, whereby the European buyer could ensure his obtaining a better and more uniform grading of hemp and the Indian agriculturist a more remunerative price than that he has been getting so far. For the purpose of putting the Indian agriculturist in a position to place on the European market a more valuable article it would be necessary, firstly, to impress upon him the importance of improving his present method for the preparation of the fibre and to try to bring home to him the advantages which are bound to accrue if such improved methods are adopted; and, secondly, to adopt such measures as will put a stop once and for all to the transporting of hemp from one producing district to another. The result of these measures should be that on the one hand the agriculturists will be able to place on the market the genuine article of the district, while on the other the cessation of the inter-district traffic will prevent any unscrupulous admixture detracting from the real value of the superior fibre. The fibre produced in each district would have to be sold and bought on its own merits; if the fibre were of a good quality it would be bound to realize a relatively higher price, and the higher the price the bigger would be the agriculturist's profit. And here arises a very important question. Supposing the agriculturists do succeed in turning out a superior fibre, and supposing also that it is possible to successfully put a stop to the transporting of hemp from one district to another, would that be a sufficient guarantee that the European trade will get the genuine article, and that after it has reached the port of shipment it will not be so manipulated as to render the efforts of the agriculturists and the authorities alike nugatory. The only way, therefore, and perhaps the most successful way of obviating this risk would be for the hemp growers of each district to adopt a co-operative system of handling their produce on lines similar to those prevailing in Norway, Sweden, Australia and other countries in connection with dairy and other agricultural products. By this method the product of a district would be collected and entrusted to some individual or firm conversant with the intricacies of the trade whose duty it would be to grade the hemp and dispose of it to European buyers to the best possible advantage of the agriculturists. So far as the hemp industry is concerned it should be easy enough to work it on the co-operative system, and the benefits which would accrue therefrom to the agriculturists would undoubtedly be very great.

In the literature bearing on the earlier stages of the Indian hemp industry, instances are freely quoted of the fibre having been valued at prices compared with which the prices now paid by the European trade are very poor indeed. This is due not to any lack of the sense of appreciation on the part of the European buyer, but to the fact of the fibre being very often manipulated to such an extent as to render it almost impossible for the European trade to secure any really superior quality of fibre, and as in the case of all other produce so also in the case of hemp the question resolves itself into one of value for quality. If therefore the Indian agriculturists could be got to produce and turn out better qualities of fibre the European buyer would no doubt gladly respond by paying higher values. The hemp industry is one with a great future before it, and one which deserves to be fostered and expanded.

THE INDIAN SUGAR INDUSTRY.

BY

WYNNE SAYER, B.A.,

Assistant to the Agricultural Adviser to the Government of India.

I. INTRODUCTION.

THIS article is written with a view to giving a concise statement of the progress up to date of the work in India on sugar and the machinery connected with it so as to enable the ordinary reader to take in a short time a general view of the progress in every branch of the industry and to see the particular points on which attention is to be concentrated in the future, without the trouble and labour entailed in wading through the voluminous literature on the subject a great part of which is either out of the reach of the ordinary reader or so technical as to baffle his search for a precis of facts. To any one desirous of obtaining further information on this subject, the writer would recommend to consult the publications of the Imperial Department of Agriculture in India and the other works too numerous to mention on the subject by different authors in India.

The steady increase which the importation figures for cheap white sugar in this country show is a matter for grave consideration, and the question of how best to strengthen the position of the Indian Sugar Industry so as to enable it to compete successfully with its principal rivals, Java and Mauritius, has been actively engaging the attention of Government during the last five years.

India is the largest producer of sugar (crude cane sugar, mostly in the form of *gur*) in the world. The annual production in round numbers amounts to 3 million tons, cane sugar and *gur* about 2,600,000 tons; palm sugar close on half a million tons. But the annual consumption is over 3¾ million tons which leaves a deficit of over ¾ million tons which is met by importation of white sugar from Java and other sugar-producing countries. Our imports of this commodity amounted in 1913-14 to over 800,000 tons.

While it is true that some part of these imported foreign sugars is utilized for mixing with *gur* to give it the appearance of country-made sugar so as to command the higher price which some people are willing to pay, and the sweetmeat makers take an increasing quantity of white sugar as the pure white colour suits their trade, yet there is no doubt that in consequence of the changes in taste resulting from the educational and economic development of India an increasing amount of refined sugar is being consumed in this country.

But while the market for refined sugar is expanding yearly, this by no means indicates that the demand for unrefined sugar or *gur* is decreasing. The general rise in wages and the increased value of agricultural produce have enabled a large number of cultivators and the labouring population to increase their demand for this commodity, and as things stand at present it looks as though the demand from this quarter will steadily increase. At any rate, as this form of raw sugar is both nourishing and cheap and enters into many Indian food preparations, it is safe to assume that for some considerable time to come the market for good *gur* will remain steady.

It is sometimes asked: can India, besides satisfying her demand for raw sugar, produce the 800,000 tons of white sugar imported from abroad? The official forecast of the current year's area sown with cane is about 2½ million acres so that if India is to be made self-supporting the cultivation of this crop would have to be enlarged by about 25 per cent. on the existing cultivation, or manufacturing yields should be increased so as to produce the required quantity of both raw and white sugar. It will at once strike any one who has studied the conditions under which sugarcane is grown and jaggery manufactured in this country that the margin for improvement is so enormous that it is not necessary to take the land from other food crops to increase the total outturn.

In India with its 2½ million acres under cane there is room for both *gur* and sugar. But the losses in extraction and manufacture should be brought down to a minimum. To give an instance of the waste taking place at present it is calculated that the amount of sugar burnt in the megass as fuel and the loss of sugar from direct heating over the fire is nearly equal to India's imports. This is one of the consequences of the cultivator assuming the rôle of a manufacturer which, it may safely be said, he has not taken up as a matter of choice or from natural aptitude. If the maximum quantity of white sugar is to be obtained factories run on up-to-date methods should be multiplied in tracts where cane cultivation is concentrated. These factories should put up powerful machinery for crushing cane so as to obtain the largest possible extraction, and evaporation should take place in vacuo and not in open pans.

It will thus be seen that while in all other sugar-producing countries attention is concentrated on the realization of the greatest amount of sucrose (white crystallizable sugar), in India we manufacture two sorts of product, *viz.*, pure refined sugar and jaggery or *gur*, which latter is a mixture of crystallizable and uncrystallizable sugar. The *gur* which is most prized for consumption generally has a light colour and good flavour. But it does not necessarily have a high standard of sucrose. There is a great variation in prices of jaggery throughout India which is to some extent due to differences in quality and appearance and also to local tastes and prejudices.

It may be noted that a good quality *gur* manufactured for direct eating is not quite suitable for refining. The good quality *gur* as mentioned above does not necessarily have a high sucrose content which is the *sine qua non* in the *gur* intended for refining. Further, in order to produce light coloured *gur* suitable for eating it is necessary that lime should be very sparingly used, while for the *gur* which is ultimately to be refined larger quantities of lime are required to produce a stable chemical composition. Juice of good colour and a moderate coefficient of purity is the best for good eating *gur*, whereas it should be of high purity for the manufacture of jaggery for refining. Soft and well crystallized *gur* is well suited for refining. Extremely hard and burnt *gur* never goes through the refining process at all. While the production of sugar direct from the cane is to be encouraged, as it is more expensive first to make jaggery and then to refine it than it is to extract sugar direct from the juice, still it may not be out of place to mention that as jaggery can be refined with the loss of about 25 per cent. raw material in the process and as the crushing season lasts for about 4 months only and some factories use jaggery for the remaining part of the year to keep them going, any large increase in the manufacture of *gur* coupled with a fall in its price will enable the refineries to work at a profit and so increase India's production of sugar.

At present the refining industry is limited as the losses incurred in the refining of raw sugar are serious. Firstly, the quality of the raw sugar usually offered by cultivators for sale is so poor that it yields a low percentage of sugar when refined. Secondly, if the refinery is to be kept working throughout the year the raw material has to be stored with the resulting deterioration so that it not unfrequently happens that when refining nearly 50 per cent. comes out as molasses. This leaves very little margin of profit unless money is made out of molasses. It is said that in Java a large quantity of the molasses is allowed to run to waste, but the methods adopted in a country so favourably situated for sugar production cannot be recommended for use in one where a profit must be made out of everything if the industry is to get a firm hold. If the inverted sugar is utilized in the manufacture of spirits or denatured alcohol for industrial purposes, or if molasses is mixed with the megass and sold as cattle food or mixed with the meal from the oil-seeds and crushed and compressed into cakes or cakettes it will materially assist in the expansion of the industry in this country.

The increasing imports of foreign sugar have threatened with extinction that part of the indigenous sugar industry which makes white sugar from *rab,* an industry of some importance in the United Provinces.

To give an idea of the amount of waste occurring in the Khandasari system it may be mentioned that by this process about 3·33 maunds of sugar are obtained from 100 maunds of cane. By following up-to-date methods the Pilibhit factory obtains 7¼ maunds of sugar from 100 maunds of cane.[1] As it is not economical to make *rab* first and then to refine it, it would be much better if a number of cultivators in co-operation with the *Khandsaris* could purchase a steam power-mill and put up small factories at suitable centres. Mr. Hulme, Government Sugar Engineer Expert, has suggested that if funds allow a triple mill (nine rollers with crushers) extracting 90 per cent. would give the best results ; failing that, a six roller mill with an extraction of 80 per cent. may be installed. Its minimum crushing capacity should be 270 maunds per day, *i.e.*, about 80 acres in 100 days.[2] These factories will not be able to make sugar to compete with foreign sugar but they could supply such sugar as is now made by country methods for consumption by orthodox Indians and for which higher prices are paid than for factory-made sugar.

It is true that the larger the factory the better it pays. But that small-sized modern factories crushing about 100 tons of cane a day can be made to pay is evident from the successful working of the factory at Pilibhit which has been remodelled under Mr. Hulme's supervision. It is also suggested by Mr. Hulme that if a seed-crushing and oil-extracting plant were combined with the smaller sized factories so as to utilize some of the machinery and the skilled staff during the off season, small modern factories crushing about 1,500 of maunds of cane per day would also have a better chance of success. The seeds are locally available and a market both for oil and cakes can be developed.

II. SUGARCANE CULTIVATION IN INDIA AND ITS IMPROVEMENT.

We may now proceed to a consideration of the defects in the present methods of sugarcane cultivation. The first point that will claim notice is the extremely low yield of cane per acre. In Java the average yield is 42 tons of cane per acre capable of yielding 4$\frac{3}{10}$ tons of white sugar while in individual cases yields as high as 60 tons of cane are obtained. The Director of the Experiment Station at Pekalongan confidently looks forward to an average production of as much as 7 tons of sugar per acre in the future. In a favourable year one mill has actually reached that figure for one month's working. In Northern India 8-12 tons of thin cane and 14 tons of thick cane may be taken as an average yield per acre. The average yield is better in Southern India, being 25 tons of cane an acre with an average outturn of 2¼ tons of unrefined sugar.

---

[1] Hailey, H. R. C., "The Sugar Industry in the United Provinces." *Report of the Ninth Indian Industrial Conference*, 1918.

[2] *Agricultural Journal of India*, Vol. X, p. 59.

Parts of Madras, Bombay and Mysore are well suited for sugarcane growing, being well within the tropics with the temperature uniformly high throughout the year. The rainfall is however of such a nature that irrigation is needed to supplement it.

Thick canes predominate in these parts and yields are large. Great care is often taken in cultivation and the crop is heavily manured with oil-cake and good profits are obtained. To cite an instance. In the area under canals in the Bombay Presidency the net profits obtained from the cultivation of the soft yellow green variety *pundia* which requires plenty of manure and copious irrigation are from Rs. 100 to Rs. 200 or more per acre. 35 to 40 tons of striped cane per acre giving from 8,000 to 10,000 lb. of *gur* being obtained in 11 to 12 months after planting. Yields of 40 tons of cane and 12,000 lb. of *gur* are not uncommon. Its analysis as given in *Bulletin No.* 61 *of the Department of Agriculture Bombay*, is:

Sucrose in 100 lb. cane	15·310
Reducing sugar in 100 lb. cane	0·672
Fibre in 100 lb. cane	10·407
Moisture in 100 lb. cane	72·521
Ash and nitrogenous matter in 100 lb. cane ..	1·090

But though the quality is so good the crop is relatively unimportant in Peninsular India. The area under it is small and is limited by the amount of water available and the quantity of paddy grown and there are no indications pointing to any very large increase in cane cultivation in those parts except where new irrigation facilities have been provided. The case is different in Northern India where the United Provinces, Punjab, Bihar, Bengal and Assam claim nearly 90 per cent. of the acreage under this crop. As this region is outside the tropics the amount of warmth and especially the length of the growing period are insufficient. While the field canes in Southern India are often comparable with those of tropical islands in thickness and vigour, those of North India are much thinner, more fibrous and much less productive of sugar. The cultivation of sugarcane in the south is intensive and costly; the crop in the Gangetic plain has very little attention paid to it.

The question now arises whether success may not be obtained most rapidly and economically by replacing the inferior canes in North India with better kinds. Dr. Barber has touched upon this point in his article on "Some Difficulties in the Improvement of Indian Sugarcanes."[1] There are four ways in which the improvement of local canes may be attempted. One is by the introduction of exotic canes which have proved of value elsewhere. This method has proved successful in Madras, where the striped Mauritius and Barbados seedling cane No. 208 introduced in the Vizagapatam district have come into great favour with the cultivators. The introduction of the red Mauritius cane through the Samalkota Agricultural Station has revived sugarcane cultivation in the Godavari District. The same variety has also supplanted the local striped cane in parts of South Arcot.

In the United Provinces a Java variety known as J. 33 is being grown by Mr. Clarke on the Government Sugarcane Farm at Shahjahanpur and gives promise of becoming a very suitable cane for those parts if not for other regions in North India. It has also been found that selected varieties of thick canes can be grown in these Provinces if proper cultivation and irrigation are given. These canes are much cheaper and easier to work from the manufacturing point of view and have a higher sucrose content and give a heavier crop than the *desi*. As an instance a Mauritius variety, Ashy Mauritius, may be quoted. This variety was selected from a number of imported varieties and has been grown for some years under the best and most intensive cultivation possible. In 1912 it yielded under these conditions 30 tons of cane and 101 maunds of *gur* per acre and contained 13·05 per cent. sucrose in the canes while the local *ukh* varieties were only giving 30—40 maunds of *gur* per acre.

---

[1] *Annals of Applied Biology*, Vol. I, Nos. 3 and 4.

At Jorhat in Assam three Barbados varieties B. 147, B. 208, B. 376 and striped Mauritius have shown their superiority as producers of high purity juices and these are being planted on the special Sugarcane Experiment Station in North Kamrup.

But this method has limitations which are mostly due to the inability of these introduced canes to stand adverse conditions of local agriculture.

The second method is the transfer of canes from one part of the country to another. This has been tried and met with limited success mainly because the introduced canes cannot hold their own against the best local kinds which are themselves the outcome of centuries of selection by the cultivators. The improvement of local canes by selection and the observation of sports and the production of seedlings are the most promising lines and are receiving special attention at the hands of Dr. C. A. Barber, Government Sugarcane Expert, who has raised over 40,000 seedlings during the past two years at the Government Farm, Coimbatore. It is hoped that in course of time a few all-round useful canes will be available for supply to Agricultural Stations in the North for a renewed series of tests there before they are given out to cultivators.

Certain practical conclusions arrived at by the Agricultural Departments may now be briefly stated. It has been proved that sets from plant cane are superior to those from ratoon cane and that the use of terminal sets for planting will produce more vigorous growth of cane than sets of any other part of the stalk. In Java some fresh tops are brought to the plantation every year. More attention should, therefore, be paid to the choice of sets for planting. The number of sets planted per acre can also be reduced with advantage in certain parts. Again the quantity of water used for irrigation is excessive in some parts. Manuring should be on a more liberal scale, and calculated to supply as much nitrogen as is absolutely required. In the Deccan canal-irrigated tracts the tendency is to apply more nitrogen than is required.

The line of improvement in Northern India seems to be better cultivation, especially in the direction of ridging and drainage, liberal use of manures, including oil cakes, green manuring and introduction into suitable localities of better varieties which not only give higher yields but are also more resistant to disease.

III. EXTRACTION OF THE JUICE AND ITS CONVERSION INTO *gur*.

We may now turn to a consideration of the extraction of the juice. The old wooden and stone mills for crushing cane have by this time almost everywhere been supplanted by iron mills with the result that the percentage of extraction has risen. But even now there is much scope for improved milling. At present much of the juice passes away in the megass because these rollers have a tendency to assume a slightly concave form after they have been in use for any length of time and this leads to a deterioration in milling efficiency. The metal of which these mills are made is soft. It would be interesting if, as suggested by Mr. Shakespear of the Cawnpore Sugar Works, a trial were made with case-hardened steel rollers, if this has not already been done, with a view to test whether uniform milling efficiency is thereby obtained. These mills are more costly, but if they are found successful in extracting more juice it will not be difficult to arrange for their gradually replacing the present mills.

Mr. Clarke, the Agricultural Chemist to the Government of the United Provinces, carried out interesting experiments at the Partabgarh and Shahjahanpur Experiment Stations, with regard to the efficiency of small iron mills at present in use in India. The results have been published in *Pusa Bulletin* No. 42. These show that a very high extraction can be secured if the *best type* of 3-roller bullock mill is working *properly*. For single dry crushing it is doubtful if it could be exceeded by any type of mill. But to secure this the strain on the bullocks is great and the rate of crushing slow. The cultivator with his light and underfed bullocks slacks off the mill and the result is inefficiency in extraction.

It is generally the case that when planting cane a ryot is guided by the amount of bullock power he has at his command for crushing it. The case for power crushing is therefore strong as it not only eliminates the losses occurring in juice extraction by bullock mills, does the work more quickly and at a much cheaper rate and gives relief to the overworked bullocks at a time when other agricultural operations require their services, but will also enable the cultivator to put down the maximum amount of land under sugarcane and will lead to a concentration of the cultivation in the near future.

In modern factories we have multiple Roller Mills weighing some 700 tons for crushing cane, whilst in comparison with these the bullock mills of India are such that a strong man can lift them. As mentioned by Mr. Hulme these multiple Roller Mills extract some 30 per cent. more juice from the cane and from this it is obvious that any scheme to improve the indigenous methods of the production of jaggery must include power-driven mills, for there are few industries in any part of the world which will stand a deliberate 30 per cent. loss of material which has to be charged to one stage of the operations—crushing, and with an industry in a by no means consolidated position like that of sugar in India, such a waste at one stage seriously imperils the whole undertaking from a financial point of view.

In parts where sugarcane is not sold direct to sugar factories it would seem that the best road to an improvement in the extraction of juice and jaggery manufacture lies in the fostering of the co-operative principle so that the crushing of the cane can be concentrated and scope may be found for the working of small power plants with more efficient evaporating appliances.

Evaporating plant for dealing with large quantities of juice in the making of *gur* is at the present moment in a state of evolution. The old Fryer's concretor is considered very satisfactory in its results as far as quick evaporation is concerned, but it is doubtful if it could effect a complete defecation and evaporation of the juice without fuel beyond that supplied by the cane. It is understood that there is a new apparatus on the market which has been installed with satisfactory results in Formosa for making Chinese sugar which corresponds to a certain extent with our Indian *gur*.[1]

The manufacture of *gur* as carried out by cultivators suffers among other things from the overheating of the juice causing caramelization and inversion caused by acidity of the juice. It may, however, be mentioned that some improvements in the boiling pan and furnace have been made in India. As the result of his experimental work Mr. Chatterton has evolved a system of manufacturing jaggery in small power-driven mills the use of which will enable the sugarcane growers to obtain 30 per cent. more from their cultivation than they have hitherto done. Mr. Chatterton has described in some detail his latest type of jaggery furnace in which there are four sets of three pans in tiers. Each tier of pans is heated by one furnace to which no firewood but only dried megass is fed. An abstract of the work of such a furnace with average cane is as follows:—

The lower pan in which the jaggery is finally formed can be emptied every 1½ hours. An average output of 6,250 lb. of jaggery per day of 24 hours can be turned out. The engine is 12 H.P. The mill has 12″ × 18″ rollers and can crush 1 to 1½ tons of cane per hour. Much, however, depends on the skill of the men feeding canes into the mill. The actual cost of making jaggery by this plant according to Mr. Chatterton is annas 2 per 25 lb., while according to ordinary methods it would cost not less than 4 annas for the same quantity. The minimum quantity of cane which such a plant must crush in a season to pay for manufacture, depreciation, and interest is about 1,500 tons. It would therefore seem that about 150 acres within reach are required in Northern India to make its use profitable. About 75 acres will do in Southern India as the yield there per acre is comparatively heavier. If the power-driven mill be worked by a number of cultivators on a co-operative basis it would pay them to instal a smaller size mill for so small an area as 40 acres in Southern India.

---

[1] Neilson, W. "Note on Indian Sugar Industry" *Proceedings of the Board of Agriculture in India*, 1911, p. 83.

A few power mills are now in use in some parts for *gur* making. In 1912 a trial central jaggery manufacturing station was installed by the Director of Industries, Madras, at Singanallur in which greater rapidity of milling and the complete saving of firewood are attained. In Mysore there are at present ten sugarcane crushing plants driven by gas or oil engines and it is anticipated that about ten more will be started during the next few months. At least ten power cane crushers are at work in the Bombay Presidency and the use of improved furnaces and more economical crushing mills is being successfully demonstrated by the Local Department of Agriculture. The charges on these power plants can be very largely reduced if something were done with the engine in the off season such as attaching rice hulling or oil-pressing machinery to these plants.

As regards the prolongation of the crushing season by arranging varieties of cane at different times of planting, etc., it appears that Dr. Barber had tried it at Samalkota without success and Mr. Neilson, the Manager of the South Indian Sugar and Distilleries Co., had done the same in South Arcot. The cane did not grow properly and the most they could do was to get a four months crushing season.[1] In Mysore it appears that the crushing season is longer. In Bihar Mr. Taylor has found that while the canes known as *Khari* and *Shakarchynia* ripen very early and give good sweet juice even as early as December, dwarf canes such as *Mango*, *Hemja*. and *Rheora* ripen more than a month later when grown under the same conditions of cultivation. These dwarf canes in fact were found not to ripen till the middle of February and showed their maximum sugar content early in March. It would therefore seem that the judicious selection of varieties will help to prolong the period of working of a Central Factory in Bihar.

Cane in the Central Provinces is ordinarily planted from January till the end of March. But the results of experiments (*vide* Messrs. Clouston and McGlashan's article in the *Agricultural Journal*

---

[1] Proceedings of the Agricultural and Trade Conference, Madras, December 1914, p. 154.

of India, July 1915), have shown that cane planted in October gives a much larger yield than that planted in February and March as practised locally. When planted in October it gets a good start before the hot weather sets in and being 4′—5′ high in February escapes the damage arising from stem-borers and red rot during the months of February and June. This indicates that there is scope in the Central Provinces for the extension of the planting season. A factory situated in a favourable locality in these parts would thus be able to prolong its working season.

IV. Central Factory System.

There are two systems under which sugar is grown and made, one the "plantation" system of the West Indies, the other the "Central Factory" system which is a more recent one introduced in various countries. In the Plantation system, the land, the agricultural labour, the factory and the manufacturing capital, are all under one control. In the Central Factory system, with its various modifications, several independent people are bound to assist one another by legal contracts. As shown in *Agricultural Ledger* No. 12 of 1903 by Messrs. Burkill and Weinberg, there are four types of Central Factories in the sugar-producing countries: (1) co-operative central factories, cane-purchasing central factories, (2) without land and (3) with land, and (4) land-hiring central factories. In co-operative central factories, the shareholders are cultivators of cane who by joint subscription put up a factory which is in the charge of an expert manager, controlled by the Board of Directors, elected by the cultivators. It will be seen that the system of co-operative central factories in which the outside capitalist is eliminated requires capital and a developed sense of mutual trustfulness on the part of those who combine to work it, and can only be adopted where those co-operating are engaged in cane business only and have their own estates on which they can raise if necessary the capital required.

In some of the West India Islands another form of co-operation is also practised. Briefly the arrangement is this.[1]

---

[1] Note on Indian Sugar Industry and Modern Methods of Sugar Manufacture. *Bulletin No.* 60 *of the Dept. of Agri., Bombay*, 1914.

" The capital required for equipping the factory is raised by debentures bearing 5 per cent. interest. All the debentures are to be amortised in 15 years. Every debenture holder receives a certain number of ordinary shares as fully paid up. The cane growers enter into contract with the factory for keeping a certain area under cane. The factory pays a definite price for the cane. After paying the manufacturing expenses, the interest on debentures and addition to the sinking fund the net profits are equally divided between the cane growers and the shareholders.

" The principal idea of both these arrangements is that a full price is paid to the cane planters for the supply of cane. The capitalists supply money for the factory and work the factory in trust. When in 15 years the capital investment is paid off the capitalists and the planters become equal participators in the assets and liabilities of the company as well as the profits. The planters lose nothing. They get full price for their cane and as an advantage of co-operation they get half the assets in the company and share half of the profits While on the other hand the capitalists get back all the money invested and for the risk they had incurred in investing the money they get half the assets of the company and share half the profits ; so that both get full advantage of the co-operation and lose nothing."

In the case of purchasing factories they may either be factories buying the cane from cultivators or hiring the right to grow it as they desire on the land of others. The cane-buying factories exist in many parts of the world, including India. The land-hiring central factory system is the system of Java. Experience has shown that cane-purchasing factories having no land gradually develop into those owning or hiring land, to enable them to make certain of a supply of cane and also to get the best variety at the most suitable time.

This method is more businesslike than the former, for the following reasons :—

1. The land is under factory control and run for the factory, whereas the ryot grows only as much sugarcane on his land as he can spare after making provision for his other requirements.

2. All cultivation is done under supervision of experienced men, done at the right time and in the right way. The ryot may, on the contrary, be a good or a bad farmer and his crop results vary accordingly, with the result that the factory has to take over a mixed lot of cane.

3. The dates of the crops are fixed months ahead, and the factory in consequence can work for periods planned beforehand to be at once economical and convenient.

It takes little acumen to realize that a factory following this method can outdo another having no guarantee for the sufficient supply of cane at fair rates and it becomes a problem how to keep the factory paying and the ryot in that state of freedom and independence which is the *sine qua non* of a flourishing agricultural population. In Java and Formosa where the sugar industry pays best, practically speaking, facilities are given to sugar mills at the expense of the cultivators.

We may now turn to a consideration of the question where central sugar factories of the modern type can be established in this country. The tracts where the cultivation of sugarcane is concentrated are parts of the United Provinces and Bihar. The area under sugarcane is rising in the United Provinces and as the increasing imports of foreign sugar have led to the abandonment of a large number of small indigenous factories which formerly made sugar from *rab*, more of the cane crop is available for conversion either into *gur* or the manufacture of sugar direct. Here the cultivators are not unaccustomed to selling their cane and it will not be a difficult matter to get sufficient supplies of cane, provided the factory pays the cultivator as good a price for the cane as he gets at present from the conversion of his cane into *gur*. The cultivators are accustomed to taking advances, but this the factory can afford to give as it materially strengthens its own position and control thereby. The quality of cane is somewhat poor, but considering the rate at which cane can be purchased in these parts it has been found that a central factory can work with profit. The geographical situation of the United Provinces which are far removed from the sea is also an advantage as the heavy transport charges on the imported foreign sugar act as a sort of protection to the indigenous product. If some sort of mechanical transport were adopted it would considerably reduce the transport charges and also enable the cane to reach the factory in good condition. At present, cultivators bring their cane to the factory in bullock carts—a slow and costly method of transport—very inconvenient for the factory to handle.

The Gorakhpur Division in the south-east of the United Provinces supplies the cheapest form of *gur* and exports about 10 lakhs of maunds of this commodity. About one-third of this finds its way to the Cawnpore refineries. The price is invariably low, rarely exceeding Rs. 3 and falling as low as Rs. 2-12-0 or Rs. 2-8-0. In 1912, prices fell to such a point that it did not pay to manufacture the cane into *gur* and some of the crop was, according to Mr. Hailey, fed to cattle. A central factory in these parts would, in the opinion of Mr. Hailey,[1] "probably be a boon to the cultivators in providing a steady market for their cane and a more profitable means for its disposal than by converting it into *gur*. If there is a profit to the refiner who has to transport his raw material long distances by rail and employ expensive fuel in refining, there should *primâ facie* be openings for properly equipped cane-crushing factories on the spot. As the surplus of *gur* and country-made sugar available for export, after satisfying local consumption from this trade block amounted to some 17 lakhs of maunds, there should be no lack of cane."

The same author has, however, pointed out that in the Uppe Doab and in Bijnor and Bara Banki districts a Central Factory would have little chance of success owing to a well-established and profitable export trade in *gur* and the prohibitive price of cane.

At Bubnoulie in the United Provinces a Central Factory has been set up with a capacity of from 400 to 600 tons. In Bihar 8 Central Factories have in recent years been erected. The erection of two or more factories is in contemplation. The production of sugar in Bihar is paying and an extension of the industry is likely as the conditions here are favourable for the Central Factory system.

---

[1] "Prices of Gur and Cane in the United Provinces." *Agricultural Journal of India*, Vol. IX, p. 225.

In the Kamrup and Goalpara districts of Assam there are tracts of waste land approaching 50,000 acres which are supposed to be suitable for sugarcane growing on a large scale. Here the question is not one of finding water for irrigation which if required could be arranged either from the numerous streams or from wells, but one of drainage which requires careful attention before any good results can be hoped for. In North Kamrup an area of about 1,000 acres has been taken up by the Agricultural Department for the initiation of an experiment in sugarcane cultivation by means of steam tackle, the object in view being to ascertain at what cost per maund cane can be produced. It is estimated that if cane can be produced at annas 5 or less per maund of 82 lb. the manufacture of white sugar by a large factory will yield a handsome profit. In the event of the experiment proving successful it is intended to hand over the concern to capitalists who will increase the area under cane and build a sugar factory on the spot. Funds have been provided for carrying on the experiment for three years but if sufficient proof of success is obtained earlier the concern will be disposed of.

In the Mon Canals area in Burma a Rangoon firm has undertaken to conduct an experiment in sugarcane cultivation under the supervision of an expert from Java with a view to discovering the suitability of the tract for sugarcane cultivation on a large scale and the erection of a factory equipped on the most modern lines. The Local Government have agreed to meet half the cost of the experiment up to a maximum of Rs. 10,000.

In the Central Provinces a lease of about 4,600 acres of Government waste land, untrammelled by any rights of tenants, has been given to Mr. McGlashan of Cawnpore, with a view to the formation of a company. Extension of sugarcane cultivation is possible in parts of these provinces where facilities for irrigation can be provided.

One of the reasons why the manufacture of white sugar in India is not making any substantial headway is that a factory in ler to be successful must be large enough, and this entails a large initial outlay. It also requires a large expert staff to work it.

In Egypt only factories with a capital of as much as £200,000 have survived and even they have found it necessary to own and control 20 per cent. of the necessary cane-growing area to steady the market, the small factories working on the system of control by advances having failed.

In India sugarcane cultivation is scattered and the quantity grown every year is subject to variation. Big sugarcane estates are practically absent except in some parts like Bihar, and the formation of new estates in the midst of areas already under specialised and highly paying crops is practically out of the question. Modern sugar factories here have therefore to deal with numerous small holders and are thus dependent upon a large number of cultivators ignorant of the business methods which a factory has to adopt. Success will depend upon the extent to which good-will and co-operation of these cultivators is secured by the manager of the factory. In Java and the British West Indies every factory either owns or has managing control over 4,000—5,000 acres of sugar plantation and can thus ensure the steady supply of raw material. In other sugar-producing countries where this is not possible and cane has to be purchased from individual planters the holdings are fairly large and the farmers are usually educated businessmen who understand how to deal with the factory in a business-like way. Even where cane has to be purchased from small holders it is only a small portion of the total cane supply.

It must, however, be said that the difficulties mentioned above are not insuperable in the United Provinces and Bihar, and that they have been overcome will be seen from the successful working of the factories established there. It is true that where cane cultivation is not concentrated but very much scattered all idea of sugar production must be given up. There and in Bombay, Central Provinces, Mysore and parts of Madras where the manufacture of *gur* pays better than sugar the working up of the cane into raw sugar must continue, but even in this there is much room for improvement.

The efficiency of large factories at work in India compares favourably with that of factories in other countries, but the raw material they have to work with is not of the same quality and it is much affected by annual weather disturbances. The indigenous *ukh* and *ganna* varieties, commonly grown, contain from 9 to 11 per cent. of sugar varying with the season. But the quality and amount of fibre is such that high extraction is not so easy as with varieties like Rose Bamboo and the thick Mauritius canes. The problem of producing white sugar will be much easier to solve if the outturn of sugar per unit area is increased by improving and intensifying the cultivation and if better varieties are selected with reference both to their actual sucrose content and their workability in the factory. It is believed that such improvements are possible even though they may take time.

Java has numerous advantages over India in the matter of cane cultivation, not the least of which is climatological. The scientific excellence of the Java sugar factories, their managers and their workmen, has long been well known. They fought through the difficult period of the sugar bounties competition triumphantly. The making of good dry white sugar direct from the cane juice is no easy matter. "Its manufacture," in the words of Dr. Geerligs. "demands not only a good knowledge of general sugar manufacture, but also special skill on the part of manager and workmen and above all a large capacity in all departments of the sugar house and a proper arrangement of the whole plant. The plant should be well designed and well constructed, and the staff and workmen should understand their work. Even the best process of white sugar manufacture will fail where the machinery is inadequate or the men incapable." In India, in the past, factories were opened which were in some cases not up-to-date and in some cases far from railways, in others far from sources of supply of raw material, and above all, they were not all under the supervision and management of practical factory managers with the requisite amount of skill and experience. Matters are, however, improving, and there are factories now in Bihar which in their working will compare favourably with some of the best factories in the world.

V. PALM SUGAR.

As India's production of palm *gur* and sugar is close on half a million tons and as this industry is capable of improvement a brief notice of the same is here necessary. In parts of Central India date trees grow wild but practically speaking the juice is not converted into *gur* or sugar. The cultivation of date palms is an important industry in Bengal. Palm *gur* and its products are largely consumed in the districts in which they are made, but in the Jessore district there are many refineries. Most of the sugar refined in Jessore goes to Calcutta and is largely used for the preparation of native sweetmeats. Mr. H. E. Annett has thoroughly investigated the condition of the date sugar industry in Bengal and published the results in the *Memoirs, Department of Agriculture, India, Chemical Series,* vol. II, no. 6. A few of his suggestions are here mentioned.

At present only 240 trees per acre are usually grown, giving a yield of 2·3 tons of *gur* but by the regular planting of 350 trees per acre an average of 3 tons of *gur*, per acre, can be obtained. It has been found that the thickest trees are the largest yielders; hence the sowing of selected seed from such trees is well worth experimenting. In the manufacture of *gur* also there is room for much improvement. The use of dirty earthen pans in which the juice is boiled is to a large extent responsible for the dark colour of the date *gur*. With iron pans jaggery of very fine quality can be produced. The aid of the principle of co-operation among date growers is here indicated. The present method of refining by means of water weed is an exceedingly slow process. If centrifugals were introduced the process would be much quicker and the turn-over much greater. The juice exuding from a freshly cut surface of the date tree contains only sucrose. Inversion takes place afterwards while it is standing in the pot overnight. Mr. Annett recommends washing the cut surface of the tree with formaline once a week and the addition of a small quantity of formaline to the pots daily. Treated in this way a very appreciable increase in yield of sugar per tree might be obtained. The substitution of cheap metal pails for the earthen pots is also recommended.

The present writer is inclined to think that if, as suggested by Mr. A. E. Jordan[1] in 1906, small steam plants for converting the juice into sugar were put up in the centres of the date tree cultivation and arrangements made to collect the juice from numerous cultivators in a tank which was then immediately treated with formaline with a view to prevent inversion, the position of the industry would be improved.[2]

In the Southern Districts of Madras and in Upper Burma the juice of the palmyra palm is converted into *gur* which is largely consumed locally. In other parts of India its juice is utilized mainly in the form of toddy, an intoxicating drink. If the value of this juice as a sugar producer be brought home to the people in these parts more interest is likely to be taken in the extended cultivation of this palm resulting in an increased output of sugar in this country.

In Madras besides the palmyra, the date-palm and the coconut are also tapped for the manufacture of sugar. But the only attempt to organize tapping and to manufacture sugar commercially direct from the juice is the factory at Kulasekharapatnam belonging to the East India Distilleries Co.

VI. Conclusion.

To conclude: It will be seen on a comparison of the figures of the last five years with those of the preceding quinquennium that substantial increase has taken place in the acreage under this crop in Northern India. In Bihar and parts of the United Provinces new factories on up-to-date lines are springing up and making the business pay. The Government Sugar Engineer Expert, Mr. Hulme, is able to guide the owners of prospective factories in the selection and installation of the most efficient kind of machinery. It should not, however, be supposed that results can be obtained in a short time, but now that the problem is being attacked systematically from several aspects substantial improvement in the Indian Sugar Industry will result in course of time. It is likely that capitalists will see their way to erecting new factories in Bihar and eastern parts of the United Provinces as the supply of cane is reasonably assured at a price which, while remunerative to the cultivators, will also enable the factories to work at a profit. As a matter of fact there are factories in Bihar, which procure good cane by purchasing in advance from cultivators and obtain excellent results. The cultivators in the neighbourhood of such factories are saved the trouble of crushing their cane and converting it into *gur*. The strain on their bullocks is thereby lessened and they are enabled to attend to other agricultural operations. In these days of specialisation the cultivator should not undertake the rôle of manufacturer as he is sure to do it badly. The factory owner should try to have at least some few acres under his own plantation and then try to increase the outturn by better cultivation, more liberal use of manures, introduction of better varieties, etc. The cultivators, when they see such results, will in course of time adopt the improvements and this will be to the material benefit of both.

---

[1] "Indian Sugar Development." *Report of the Second Indian Industrial Conference*, 1906, pp. 227-28.

[2] Since this was put in type the writer has come across the following in the recent report of the Bengal Department of Agriculture.

Government has sanctioned the purchase of a small apparatus from America such as is used there for the production of maple sugar. The plant ordered should deal rapidly with the juice of a large number of date trees. It is now on its way and is to be tried next cold weather in the Jessore District. Metal collecting buckets for the juice are also being imported. It is also proposed to collect the juice from the pots in large gathering tanks. These will be transported from distant gardens in carts or boats to the sugar-making house. This should save much labour.

Nowadays competition is so keen and prices are so cut that every possible aspect has to be considered, and in many cases it is only by the fortunate discovery of a by-product that an industry is enabled to carry on. Java has everything in its favour and will certainly not lose the Indian market without a struggle, and it is therefore up to India to face the problem—either to run the industry as a business—to make a profit irrespective of everything else, or to continue as now a state of things which cannot lead to success when put in the field against such powerful and well organized rivals.

Here in India we have an industry which badly needs more capital to enable it to expand and the fact that the Agricultural Department's experiments and the assistance available from Government sugar experts has made it possible to overcome many obstacles which formerly obstructed progress, should greatly assist in the bringing in of fresh capital which is essential to development.

A NOTE ON THE DIAGNOSIS OF GLANDERS.

BY

A. W. SHILSTON, M. R. C. V. S.,
Assistant Bacteriologist in charge of the office of Imperial Bacteriologist, Muktesar Laboratories.

In equines that become infected by the Glanders organism, the development of external symptoms of the disease is usually slow, so that only in a small proportion of cases is diagnosis possible by clinical examination alone. Since, however, affected animals, that are apparently healthy, are capable of spreading the disease not only to other animals but also to human beings, the urgent necessity of detecting and eradicating such centres of infection is very evident.

The discovery of Mallein by Helman and Kalniny in 1891, and its application by subcutaneous injection marked a great advance in the means available for the diagnosis of latent cases of the disease.

The various forms of Mallein are all prepared from cultures of the Glanders bacillus (*B. Mallei*) and contain substances which when introduced into the body of a glandered animal, provoke a general febrile reaction and symptoms of local inflammation at the seat of inoculation. In healthy animals Mallein produces little or no reaction.

The subcutaneous method of applying the Mallein test has been relied upon almost solely in Great Britain for the suppression of the disease and the results obtained during the past ten years are certainly sufficiently convincing to warrant the confidence with which the test is regarded; the number of outbreaks, as recorded in the

Board of Agriculture report for the year 1914, has fallen steadily from 1,529 in 1904 to 162 in 1913 and 97 in 1914.

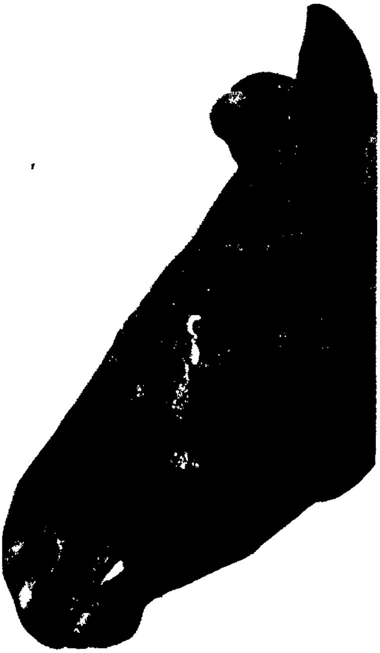
It had early to be admitted however that, in addition to certain recognised conditions under which the Mallein test is unreliable, there were a small percentage of infected animals which failed partially or completely to respond to a subcutaneous injection of the agent.

Accordingly, numerous investigators sought to find other means of diagnosis to replace or supplement the subcutaneous test and several interesting and delicate methods were devised. Some of these depend on the demonstration of specific substances in the blood serum of infected animals, but since they are essentially laboratory tests, their description is outside the scope of the present article.

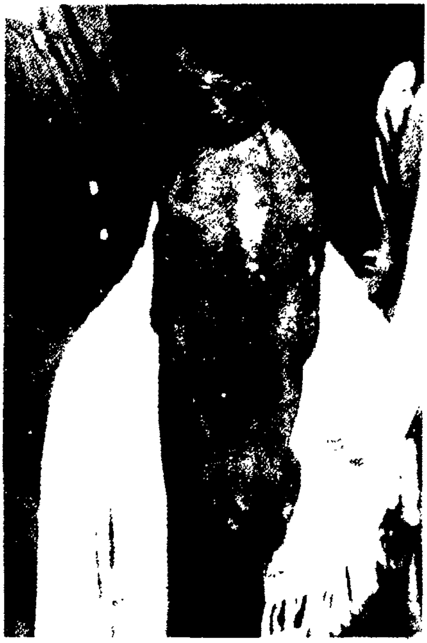
The two methods to be described are modifications of the Mallein test which owe their characteristic features to the sensitiveness of the tissues surrounding the eye, and the inflammatory response produced in glandered animals by the introduction of Mallein into these tissues; they are known respectively as the "Ophthalmic" or "Conjunctival" and "Intra-dermal-palpebral" reactions.

The ophthalmic test was introduced in 1907 by Vallée and quickly gained favour on the Continent and in America as a reliable and easily applied diagnostic method for use by practitioners and State veterinarians. It is now the official test in the United States, Austria, Bavaria, Denmark and other countries where it has almost entirely superseded the subcutaneous Mallein test. In cases of doubtful reaction, the older test is sometimes employed, but the usual practice is to send serum from the suspected animal to the laboratory for testing by one or other of the more delicate serum methods of diagnosis.

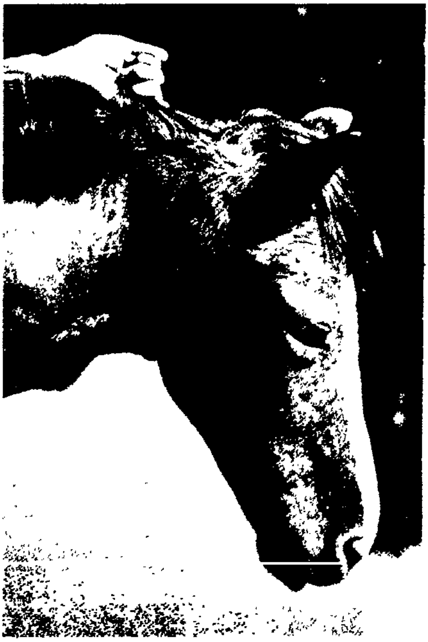
For the ophthalmic test specially prepared concentrated Mallein is required; this is supplied in the form of a dark brown viscid liquid or as a light brown powder (Mallein siccum) which must first be dissolved in a definite quantity of sterile water, supplied with the powder. Before applying the test both eyes must be examined to



OPHTHALMIC TEST.
PONY 105.
Eye reaction 18 hours after application of Mallein to conjunctiva; purulent discharge and partial closure of eye.



INTRA-DERMAL PALPEBRAL REACTION.
PONY 132.
Twelve hours after injection of *0·2 c.c.* of Mallein.



INTRA-DERMAL PALPEBRAL REACTION.
PONY 121.
18 hours after injection of *0·2 c.c.* Mallein into

ascertain that no inflammation already exists; if this is found, the test should not be carried out. Provided the eyes are normal, two or three drops of the Mallein are introduced within the eyelids; this may be done with the aid of an eye-dropper or, preferably, on a camel hair brush, the inner surface of both the upper and lower eyelids being gently smeared with the liquid. Only one eye is treated, the other serving as a control for comparison of the reaction.

Immediately after the application there will be some lachrymation and reddening of the conjunctiva, but these symptoms will disappear in an hour or two, and in a healthy animal nothing further will occur.

In a glandered animal, the characteristic reaction commences usually about the sixth hour and lasts from twenty-four to thirty-six hours or longer. It consists of a purulent discharge from the conjunctival sac which collects at the inner canthus of the eye in yellowish lumps and may run down over the face; there is also reddening and some swelling of the conjunctiva, with occasionally gluing of the eyelids. To judge the result, the tested animal should be examined from twelve to twenty-four hours after the application of the test. The reaction varies in degree in different animals but only a purulent yellow discharge is to be considered positive of Glanders. When there is nothing more than a greyish slimy discharge and slight inflammatory reaction, the case is doubtful and a second application may be made to the same eye in 24 hours when a definite conclusion can usually be arrived at. If not, the subcutaneous test may be carried out or the ophthalmic test repeated in two or three weeks. Care must be exercised to ensure that the attendant does not wipe away any discharge that may occur. Only in a proportion of cases, usually those giving a marked eye reaction, is there any febrile disturbance so that in practice it is not necessary to record temperatures. The existence of slight fever does not interfere with the application of the test.

The ophthalmic test may be applied 24 hours after the subcutaneous test has been performed, but is more reliable if carried out before the latter: the subcutaneous test influences to some *extent a subsequent* ophthalmic test and may seriously affect later *serum tests, but the ophthalmic test has no effect on any other diagnostic method that may be carried out afterwards*; this is one of its chief advantages. The ophthalmic and subcutaneous tests may be carried out simultaneously but during the height of the fever reaction the conjunctival symptoms may cease, usually, however, to appear again when the fever subsides. In cases where an ophthalmic reaction is followed within two or three days by a subcutaneous test, it will frequently be observed that inflammatory symptoms again appear in the eye that was previously tested.

A drawback to the employment of the ophthalmic test in India is the frequency with which animals show slight conjunctivitis, the result most probably of the entrance of dust; in such cases the subcutaneous or intra-dermal-palpebral test will have to be carried out.

In mules the subcutaneous test appears to be less reliable than in horses, so that in addition to the simplicity of its application and the avoidance of the troublesome process of temperature taking, the ophthalmic test would seem to be particularly suitable for application to these hybrids; where large numbers of equines have to be tested rapidly, as at Remount Depôts, the method could also replace the subcutaneous test with advantage.

The intra-dermal-palpebral test is the latest form of Mallein application and was first suggested by an Italian veterinarian, Lanfranchi, in 1914. It has been employed very largely in France during the past year and reported on most favourably. The method is really a combination of the subcutaneous and ophthalmic tests and unites the advantages of both without, it is said, their disadvantages.

The ordinary Mallein, as used for subcutaneous mallination, is employed, but the dose given is only 2 minims or 0·125 cc. instead of 1 cc. as in the older method.

The dose being small, a 1 cc. syringe, Record or other reliable pattern, graduated to $\frac{1}{10}$ cc., is necessary and care should be taken not to inject more than 0·2 cc. of the Mallein. The injection is made into the depth of the skin of the eyelid, usually the lower, though it appears to be immaterial if part of the dose is injected into the loose connective tissue between the skin of the lid and the conjunctiva; for this purpose a fine short needle is required, such as is used by human surgeons or dentists; in this case few horses make much objection to the insertion of the needle. To avoid risk of piercing the lachrymal sac, it is well to direct the point of the needle backwards when injecting the lower lid.

In animals free from Glanders, a slight swelling of the injected lid may persist for a few hours, but this will have disappeared by the twelfth hour.

Glandered animals exhibit a characteristic reaction which commences about the ninth hour, reaches its maximum between the twenty-fourth and thirty-sixth hours, and may persist for three or four days. The injected eyelid becomes swollen and painful and the other eyelid may become similarly affected. The conjunctiva is inflamed and a muco-purulent discharge accumulates at the inner canthus of the eye; the œdema of the eyelid and sensitiveness to light causes partial or complete closure of the eye.

The reaction resembles that obtained by the ophthalmic test, but owing to the swelling of the eyelid is more pronounced and persists for a longer period. At the same time there is a thermic reaction similar to that following a subcutaneous injection of Mallein; this appears to be much more constant than in the ophthalmic test so that temperatures may with advantage be taken at the usual intervals. When a doubtful reaction is obtained the test may be repeated on the other eye, forty-eight hours later.

The subcutaneous test should not precede or follow the intra-dermal-palpebral test by a shorter interval than three weeks, but the two tests may be applied simultaneously without any interference with the reactions of each.

The experience in France is that this test is more reliable than the subcutaneous test, requires a smaller quantity of Mallein and may be carried out without the labour of recording temperatures at short intervals; one examination twenty-four hours after the injection is usually sufficient to arrive at a definite conclusion.

Moreover, in a country where the high atmospheric temperatures and exposure to sunlight have a marked effect on body temperature, thermic reactions cannot be relied upon, so that an unmistakable local manifestation is of great advantage; the most striking and reliable is undoubtedly obtained by the intra-dermal-palpebral method, when accurately applied.

Concentrated Mallein for the ophthalmic test, as well as the ordinary variety for the subcutaneous and intra-dermal-palpebral tests is supplied from the Imperial Bacteriological Laboratory, Muktesar, United Provinces.

CLOVER AND CLOVER HAY.

BY

A. HOWARD, C.I.E., M.A.,
Imperial Economic Botanist,

AND

GABRIELLE L. C. HOWARD, M.A.,
Second Imperial Economic Botanist.

I. INTRODUCTION.

ONE of the chief factors which limits production, in the soils of the Quetta valley, is the amount of organic matter. Immediately the proportion of this substance is increased, either by direct manuring or by the cultivation of crops like lucerne, growth becomes more vigorous and rapid and the yield materially improves. In the case of wheat, for example, the average yield of the unmanured, irrigated crop is about thirteen maunds to the acre while considerably over twenty maunds are often obtained from similar land that has been fertilized. Heavy dressings are applied to the fields near the main roads within a three-mile radius of the Cantonments, where the storage of stable manure is not permitted. Outside these areas, there is a marked falling off in production, and, where the land is only occasionally manured, the wheat crops are poor.

The physical effect of an increased supply of organic matter in the soil is two-fold. In the first place, its porosity is improved and gaseous interchange between the atmosphere and the soil is accelerated. But for the organic matter, the fine particles of the silt-like soils of the valley would pack so closely after surface irrigation as to deprive the soil organisms and the roots of crops of a sufficient supply of air.[1] In the second place, the tilth and water-retaining power of the land are improved.

The need of a fresh source of organic matter in these soils is clear. The amount of manure is limited and is likely to remain so while the benefits of a lucerne crop are restricted by the fact that it remains in the ground for five or six years and is thus of limited value as a rotation. Some crop, preferably a leguminous annual, which can make use of the winter rains and which can be used as a green manure is therefore needed to improve the general agriculture of this tract. Four such crops have been tried at Quetta during the last three years—sulla (*Hedysarum coronarium*), berseem (*Trifolium alexandrianum*), annual red clover (*Trifolium pratense*) and Persian clover or *shaftal* (*Trifolium resupinatum*). Sulla is an important fodder crop of the Mediterranean region but does not withstand the cold of winter at Quetta. Berseem grows fairly well, but does not yield a satisfactory weight of produce. Annual red clover is perhaps more satisfactory than berseem, but the growth is slow although the crop is not checked by the hot weather of July. *Shaftal* proved much the most satisfactory of these plants as it will yield four crops in one year, three of which can be utilized for fodder and the last either for seed or as green-manure. The plants set seed freely during the month of June so that there is no difficulty with regard to a fresh supply for sowing. No pests have been observed on this crop when properly grown and when regularly cut. If, however, it is overwatered and if it is not cut in time, the leaves are often attacked by a rust fungus, but this does not reappear on the foliage of the new growth unless it becomes over-ripe.

II. THE CULTIVATION OF PERSIAN CLOVER.

Provided a few simple precautions are taken in establishing the crop, the cultivation of *shaftal* presents no difficulties. The procedure follows, in the main, that which is usually adopted in the case of lucerne.

---

[1] See "Soil Ventilation," *Bulletin 52, Agricultural Research Institute, Pusa,* 1915.

Sowing. Grown under field conditions, where the young crop is exposed to drying winds, the seedlings are most easily established under a somewhat thin cover-crop of maize or *juar*. The cover-crop protects the soil from wind and sun and also allows the *shaftal* seedlings to develop quickly a strong root-system. The amount of seed required is about ten seers to the acre and, before sowing, it is an advantage to sprout it. This is done by soaking the seed in water for a few hours and then spreading it on a damp gunny bag, in a layer about half an inch thick, and covering with another damp sack. In from six to eight hours in an ordinary room, sprouting takes place and almost all the seeds just begin to show the radicle (young root). The germinating seed should then be mixed with its own weight of dry earth (to separate it for sowing) and be sown broadcast *on the irrigation water* in the *kiaris* as soon as the water is at rest. In this manner, the seeds root at once and, on the second day, germination is complete and the soil is covered with rapidly developing seedlings. A light covering of dry earth, applied as soon as possible after sowing, does much to assist the seedlings and to conserve the moisture. A second light watering should be given as soon as the surface of the ground has dried and the seedlings cease to grow. The time of sowing is important. *Shaftal* does not germinate well at Quetta until the summer temperature falls during the second half of August. Late sowings, on the other hand, do not do well on account of the cold. It is best to sow the crop during the latter part of August and to take the first cut towards the end of October or early in November. In this way, *shaftal* develops a strong root-system before the cold weather and is able to withstand the frosts of winter without damage.

Irrigation. To obtain the best yield the crop must not be over-watered. After the removal of the cover crop in early September, a good deal of water can be saved by the use of a thin earth-mulch as soon as the irrigated surface is dry enough. The earth-mulch materially assists the young crop in establishing itself and is particularly useful when *shaftal* is sown in gardens without a cover crop. As in lucerne, the need of irrigation water is shown by the change in colour of the foliage. As soon as the leaves begin to darken and the plants appear to contract so that the ground can be seen, water should be applied. During the winter, little growth takes place and the need of irrigation water is not great until rapid growth begins in the spring.

Yield. In considering the question of yield, it must be remembered that the duration of the crop is limited by the advent of the hot weather in June when *shaftal* flowers and forms seed. To obtain the maximum amount of fodder, the crop must be cut as soon as possible in the spring and as often as possible. A well-established and well-managed crop will yield three cuts of produce in the spring before it flowers at the end of May when the last growth can be used either for seed or for green-manure. Any delay in cutting tends to bring on rust and also weakens the stand. The total green crop yielded by *shaftal* on unmanured land amounts to about 60,000 pounds per acre per annum, but it is probable that on land in really good condition more than three crops and a greater weight of produce might be obtained.

Feeding value. Green *shaftal* is most suitable as a food for dairy cows and buffaloes, but it can be used for horses, mules or work cattle, provided it is chopped small and mixed with sufficient *bhusa*. If fed by itself in large quantities to these animals, it is apt to cause swelling, particularly in the spring when green fodder is scarce and animals are likely to over-eat themselves.

For some years, the *shaftal* grown at the Fruit Experiment Station has been sold to the Government Military Dairy at Quetta where it is considered the best fodder available in the district. As it yields a cut in the autumn after the lucerne crop is over and comes in again in the early spring, the clover crop extends the period during which green fodder is available.

Effect on the soil. The chief value of this crop in the Quetta valley is its beneficial effect on the soil in increasing its porosity and water-holding capacity and in improving the tilth. *Shaftal* forms a strong tap root which gives off a very extensive set of fine laterals. These penetrate the ground in all directions and so break up the surface soil. After a *shaftal* crop, the tilth improves and the soil assumes that elasticity to the foot which is so characteristic of arable land in really good heart. If the last crop is ploughed in, the amount of organic matter added is of course greater and the benefit to the soil is increased. In fruit growing at Quetta, the growth of *shaftal* between the trees during the first two or three years not only brings in a good revenue but also leaves the soil in excellent condition for the production of large crops of well-ripened fruit. Such improved soils need no manure for some years and their condition, as regards tilth and fertility, is even better than that of the heavily manured fields near the Cantonments.

Seed supply. About fifteen maunds of *shaftal* seed are produced every year at the Fruit Experiment Station for general distribution. The growers of this fodder should, however, as far as possible, keep a portion of their crop for seed as the demand is increasing rapidly.

III. CLOVER HAY.

The advantage of good hay in the feeding of horses and mules, engaged in heavy transport, is well known. In India, real hay is however rare and its place is taken by substances such as *bhusa*, dried grass or dried lucerne, which are exceedingly hard and brittle and which have not undergone the mild fermentation processes involved in the preparation of grass or clover hay.

In 1914, at the suggestion of the Hon. Sir Henry MacMahon, G.C.V.O., Foreign Secretary to the Government of India, experiments on the drying of *shaftal* were commenced with the object of producing a fodder suitable for army purposes. If this crop is to be taken up on the large scale by the zamindars, particularly in the outlying tracts at a distance from the Cantonments, it is clear that some method of disposing of it to advantage must be devised. The demand for fresh *shaftal* is limited as, apart from dairy cows and buffaloes, it is not likely to displace lucerne as a green fodder for general use. On the other hand, it appeared likely that *shaftal* could be made into good hay more easily than lucerne.

The difficulties in making good hay in an arid climate like that of the Quetta valley are considerable. The extreme dryness of the air, combined with the effects of the sun and wind, dry any green fodder with great rapidity and soon render it so brittle that it cannot be handled without breaking it to powder. Such a product cannot be fermented and an operation like baling is out of the question. The people get over this difficulty, in the case of lucerne, by making it into ropes while green. These are afterwards dried in the sun and stored. The product, however, is not lucerne hay but dried lucerne. No fermentation is possible and there is naturally a great loss of leaf involved in the handling of the dried ropes. The product has the further disadvantage that it cannot easily be baled so that it can only be used locally and is not suitable for an army on active service.

The disadvantages of the extreme dryness of the climate in making clover hay can be overcome by drying the fodder in stages. After cutting, the *shaftal* is spread out to dry for a day or two when it is turned and allowed to dry for another day. When about half dry, it is collected into heaps and pressed down firmly so as to check the rate of drying. Provided the clover is put into heaps just at the right stage, fermentation soon begins and, on the second day, the fodder begins to get warm. At this point, the heaps are opened and the produce carried to the stack during which it dries considerably. Some little experience is needed in determining the stage at which to stack the fodder. If it is too dry no slow after-fermentation takes place and it becomes too brittle for baling. If, on the other hand, it is stacked too damp, overheating takes place and the final product moulds. There is naturally a considerable latitude between these two extreme conditions in which the product can be safely stacked. Some drying takes place in the stack and this must be allowed for. When properly put up, the final fermentation in the stack is somewhat rapid and the light green product changes in colour to brownish green. At the same time, the characteristic sweet smell of clover hay is developed and the fodder loses its harsh and brittle character. Two months in the stack is ample for the development of the proper colour and texture after which the hay can be baled.

The loss in weight in the process of hay-making is naturally considerable and works out between 76 and 84 per cent. according to the stage of ripeness of the green crop. A fair average would be 20 pounds of hay to 100 pounds of green *shaftal.*

A number of bales of *shaftal* hay were prepared in 1914 and placed at the disposal of the Baluchistan Fodder Stores for use at Quetta during the past winter. Major Hislop very kindly undertook to bring the hay to the notice of the various fodder-consuming units in the Cantonments and, if possible, to get it tried in one of the batteries. This was duly carried out and a full trial of the baled *shaftal* was undertaken with the horses of the 72nd Heavy Battery, R.G.A. The Commandant, Colonel M. H. Courtenay, R.A., reported on the trials as follows (Letter dated, Amara, July 30, 1915) :—

Report on Shaftal hay at Quetta.

"Up till I left my battery (72nd Heavy Battery, R.G.A.) I used *shaftal.* I found 3 lb. *bhusa* to one of *shaftal* made an excellent chop, and the horses throve really well on it and the *shaftal* made even the shyest feeders eat *bhusa* freely. I prefer dried *shaftal* to dried lucerne and further I saved at least 25 per cent. in cost. I can strongly recommend it to any horse-owner in Quetta."

During the present year, a larger supply of baled *shaftal* has been prepared and the product is unquestionably superior to that made in 1914 and tried in the 72nd Heavy Battery. The bales have been taken over by the Baluchistan Fodder Stores and Major Hislop has kindly agreed to arrange for a further set of trials. Arrangements have been made to distribute a number of sample bales to the various units so as to make the new fodder widely known.

IV. THE IMPORTANCE OF INCREASED PRODUCTION IN THE QUETTA VALLEY.

The cultivation of *shaftal* is one of the chief means by which the production of the Quetta valley and of other parts of Baluchistan can be increased. The increased cropping power of this tract is of importance from two points of view—that of the zamindars and of Government.

From the standpoint of the zamindars, the cultivation of *shaftal* would be the means of utilizing the winter rainfall to advantage and would afford a fresh source of green fodder which, without much trouble, could be made into excellent hay suitable for use in the winter and also for sale to the Army. The fertility of the land at the same time would be increased and in a short time the outlying tracts would be as productive as the land immediately surrounding Quetta. Larger crops would result and a general improvement in agriculture would ensue. The water required for the *shaftal* crop would be obtained by growing the wheat crop on one irrigation instead of the seven now usually applied.[1]

From the point of view of Government, any marked increase in production in the Quetta valley and in Baluchistan generally would mean an increase in general revenue. At the same time, the supplies of grain and fodder in the neighbourhood of Quetta would be improved and the difficulties in providing forage for the Army would largely disappear. A supply of *shaftal* hay would go far to solve many military problems as the adoption of *baled* clover instead of *bhusa* would reduce the transport trains of an army on active service to a very considerable extent. A fodder reserve of pressed *shaftal* could easily be built up at Quetta and it might even be possible to export this material to the various Cantonments in the Punjab.

---

[1] See the article on "The Sowing of Irrigation Water in Wheat Growing," *Agricultural Journal of India*, Vol. XI, Part I, 1916.

SOME SUGARCANE EXPERIMENTS IN TRAVANCORE.

BY

N. KUNJAN PILLAI, M.A., B. Sc., Ph.D.,
Director of Agriculture, Travancore.

TRAVANCORE is not a large sugarcane growing country. Out of a total area of about 1,942,800 acres under cultivation in Travancore, sugarcane is grown only in about 10,000 acres which lie mostly by the sides of large rivers. Such lands are subject to floods during the monsoons and receive therefrom a large deposit of silt which naturally adds to their fertility. Within recent years the hills of Travancore have been explored by European planters and mostly converted into rubber and tea estates. The extension of cultivation into the hills has, as a matter of course, diminished the quantity of silt which the rivers carry down; and consequently the lands by the sides of the rivers have deteriorated, and the yield of sugarcane from them has diminished to a certain extent. Under such circumstances, the only course open to sugarcane cultivators in Travancore to maintain their yield undiminished year after year is to adopt improved methods of cultivation, and particularly scientific manuring, of their cane crop.

With a view to find out the lines of improvements best suited to the country under the conditions prevailing here, a series of experiments was carried out in one of the important sugarcane centres during the cultivation season of 1914-15. A short account of these experiments and of the interesting and important results they have produced is given below.

The experiments were conducted with three-fold objects, namely, (1) to find out the best method of planting sets, (2) to ascertain the advantages of thick and thin planting of sets, and (3) to demonstrate the most profitable method of manuring canes.

1. *Method of planting sets.* In Travancore the usual practice is that the land is prepared by ploughing or digging and is afterwards levelled and the sets are planted in small pits from 3 to 4 feet apart. Experiments in other parts of India have shown that a better method than this is to prepare the land by deep ploughing, convert it into ridges and furrows, and plant sets in furrows, the canes after a few weeks being earthed up so as to convert the original furrows into ridges and ridges into furrows. These two methods of planting sets were tried in two different plots of 10 cents each, both the plots receiving the same treatment in every other respect, and the result was that the plot in which sets were planted in pits yielded 600 lb. of jaggery (*gur*) and the other 672 lb. of jaggery. In other words the ridge and furrow system of planting sets yielded 720 lb. of jaggery more per acre than the pit system.

2. *Thick and thin planting of sets.* The sugarcane cultivator in Travancore usually plants 10,000 to 15,000 sets per acre. That this is more than what is actually required has been proved by several experiments carried out in other parts of India. The experiments in Travancore tell the same tale. Two plots of 10 cents each were taken up for this experiment; in one, sets were planted at the rate of 10,000 per acre, and in the other at the rate of 5,000 per acre. The former plot yielded 528 lb. of jaggery and the latter 600 lb. of jaggery. Thus by reducing the number of sets by one-half the yield of jaggery per acre increased by 720 lb.

3. *Manuring.* The only manure that is ordinarily used for sugarcane in Travancore is ashes, and that too not in sufficient quantity. With a view to demonstrate the superiority of a complete manure to simple ashes, two plots of 10 cents each were cultivated with sugarcane, one receiving 600 lb. of ashes alone, and the other a mixture consisting of 300 lb. of ashes, 180 lb. of oil-cakes, and 60 lb. of prawnskin (a kind of fish refuse). The yield from the first plot was 552 lb. of jaggery and that from the second plot 744 lb. Thus the application of the mixture resulted in a

net increase of 1,920 lb. of jaggery per acre. This increase, when calculated in money at the current market price of jaggery in Travancore, is equivalent to about Rs. 110. In this connection the cost of the manures must also be taken into consideration. It works out at Rs. 30 per acre in the case of ashes and Rs. 55 per acre in the case of the mixture.

It is interesting to note in passing that the best yield of jaggery in the above series of experiments was 744 lb. from a 10 cent plot, which is equivalent to 7,440 lb. per acre, and that this is not much behind the best yields obtained on Experimental Farms in other parts of India.

The conclusions that may be drawn from the experiments described above are the following:—

(*i*) Ridge and furrow system of planting sugarcane sets is superior to planting them in pits, which is the common practice in Travancore.

(*ii*) Thin planting of sets is better than thick planting.

(*iii*) The application of a complete manure to the sugarcane crop, such as a mixture consisting of ashes, oil-cakes, and prawnskin, is more profitable than the application of ashes alone.

NOTES.

RAT AND MOUSE PLAGUES.[*]—These plagues are of periodical occurrence in the Bombay Presidency and with the sole exception of the Konkan or heavy rainfall tract hardly any part of the Presidency escapes these ravages. The Deccan, in particular, has been overrun on several occasions. There are more than one species but Dr. Fairbank of the American Mission states that the three most destructive species are (1) the Indian Jerboa rat, (2) the Indian Mole rat, and (3) the large-eared field mouse. The principal rat plagues since 1874 are recorded in the Statistical Atlas of the Presidency, the worst of which occurred in 1878-80. It broke out almost immediately after the close of the monsoon in October 1878, and rapidly spread over the whole Deccan and Karnatak, December 1879 seeing it at its worst.

The crops most severely attacked were wheat, cotton, *jowar* and garden crops. The only grain saved was that which was hurriedly harvested before it was ripe. The immature bolls of cotton were destroyed. In 1879 the early crops were damaged just as badly as the late ones. Directly the grain was sown it was scratched up and eaten and this was repeated three times in many fields. After destroying the *rabi* crops the rats suddenly decreased in the month of December and by the end of March, 1880, they had disappeared as unaccountably as they had come. The plague was fostered by the religious prejudices of the people who thought that the spirits of those who had died of starvation in the previous famine were, as compensation, allowed to enter the bodies of the rats, and eat the unripe grain and seedlings which were unfit for human consumption. A caste of men known as Vaddars showed wonderful skill and patience in destroying the rats by digging them out and these men earned large rewards. As the result of Government offering a reward of one rupee per 100 rat tails, in July 1879, 16 million tails were brought in, and in the Dharwar district alone a lakh of rupees were distributed in rewards on this scale. In 1892-93 another plague of rats is recorded. It originated in the same place as the great plague of 1878-80, *viz.*, the eastern talukas of Belgaum but did not attain such serious dimensions owing to the timely advent of rain and an enormous increase of red ticks which are probably one of nature's principal controlling methods for preventing an excessive increase of rats. Digging out was again found to be the most successful artificial method of dealing with the rats. In 1901-02 also rats did enormous damage in Gujarat, Khandesh and parts of the Deccan.

---

[*] Taken from an article by Mr. T. F. Main in the *Poona Agricultural College Magazine* for October 1915.

Explanation of rat plagues.

It may be taken for granted that a plague of rats always points to the failure of some natural controlling agency which usually acts as a check on excessive breeding. In the black soil tracts where rats are always plentiful any abnormal increase in numbers is usually checked owing to the soil swelling with the first heavy rain of the monsoon, and smothering large numbers. There was an absence of heavy rain in the monsoon of 1878 immediately before the great plague, and it was observed that those tracts which had suffered most in the famine of 1876-77 also suffered most from the rat-plague. This fact also supports the conjecture that the usual underground stores of grain, brought by the rats from the ripening crops, were reduced so greatly that this shortage of stored food drove the rats to seek food on the fallows—where they increased enormously owing to the favourable season. It must be noted, however, that a wet season does not necessarily imply an absence of rats. In 1914-15 after a heavy monsoon Khandesh crops suffered severely from rats. Apart from the indirect effect of rain the most powerful check on the natural fecundity of the rat is probably the red tick referred to above. The snake and mongoose are also formidable enemies.

Damage caused by rats.

It is on record that in the great plague of 1878-80 only one-eighth of the early crop was saved in Sholapur district and that remissions of land revenue amounted to Rs. 88,480, while in the Poona district the harvests were reduced by three-fourths in the black soil tracts. In some parts of Khandesh the people did not harvest the wheat crop in 1914-15 as not a head of corn was left in the field. Mr. Gadgil reports that at Ner in Khandesh in the season of 1914-15 he found underground stores, measuring 4 feet by 4 feet and from 2 to 4 feet deep, containing as much as 16 lb. of ear-heads from which 10 lb. of grain were threshed. The Vaddars make a practice of digging out these stores to recover the grain and they also eat the rats. In Khandesh parties of Bhils were employed in 1914-15 to dig out the rat holes and recover the grain, a remuneration at the rate of one-third of the grain so recovered being given. During a plague of rats if cotton remains unpicked for a short time large quantities of *kapas* are pulled off the plants and conveyed into the soil fissures where the rats eat the seed.

Control.

As noted above the most successful method of dealing with rat-plagues adopted in the past was to dig out their burrows, but this is a most laborious process and various alternative methods have been tried. Concealing arsenic, barium carbonate or glass in small pieces of food has been tried but has not proved effective due—(1) partly to the fact that there is abundance of good food and hence any addition to it does not make any special appeal to the rats, and (2) the natural instinct of the rats, which undoubtedly warns them against such food after the first few deaths. The invariable experience with poisoned baits has been considerable success for a day or two followed by failure. Trapping is not practicable, the numbers being too large. The most efficient weapon which we have so far discovered for use against field rats is fumigation. At Nadi a

Mr. Jhaveri who conducted the experiments happened to possess a white ant exterminator consisting of a vessel within which charcoal and sulphur are burnt and to which is attached a flexible wire tube and pump for discharging the sulphur fumes into the rat holes.

The procedure of fumigation.

In practice it is usual to find that several holes are connected one with another by run-ways in all directions, and it is necessary to stop up all bolt holes before pumping in the sulphur fumes. The machine is then worked for about three minutes. For this purpose one *tola* of sulphur powder per hole is required and about sixty to eighty holes can be fumigated in a day by a party consisting of two trained coolies at a total cost * of less than one rupee in *goradu* (sandy) soil. It was feared that fumigation would prove difficult in the black soil where large cracks extend in every direction, but it has been found possible to work it on these soils if an extra coolie be employed to assist in scraping loose soil over the cracks. In this way it was found that the sulphur fumes spread through an area varying from one-tenth to one-half *guntha* according to the length and width of the fissures and for this purpose 1½ to 2 *tolas* of sulphur were used, the time required for such an operation varying from 5 to 7 minutes.

* Items.

Wages of two coolies at 5 annas ..	R.	0	10	0
Cost of 1¼ lb. of sulphur		0	3	0
Cost of charcoal		0	1	6
Total ...	R.	0	14	6

A white ant exterminator is a rather expensive machine, costing some sixty-eight rupees when imported, but it is hoped to get suitable machines made in the Presidency at a much lower figure.

⁂

INDIAN HYOSCYAMUS.—The great European war which has now been raging for over seventeen months has brought the world face to face with many economic problems which have previously escaped the notice of the general public. We read of the disturbance caused in the world's dye markets and the trades depending upon artificial dyes by the isolation of Germany, and one important phase of this in Indian rural economics is that the natural Indigo trade has taken a new breath of life for the time being. Germany for the first time to the uninitiated appears in the rôle of the principal producer and controller of the world's supply of fine chemicals. Not least in importance of these are the many medicinals of which Great Britain and her dependencies now find themselves short, dangerously short. A number of these compounds belong to the class of so-called synthetic drugs—that is to say such medicines as antipyrine, sulphonal, etc., which are artificially manufactured from simpler compounds. But besides these the faculty still has to make use of a number of plant products, medicinal principles, which can be isolated only from specific plants and parts of plants like quinine from the Chinchona bark; strychnine from the *Nux vomica*; and atropine from the *Atropa belladonna*. Similar to atropine is another well known mydriatic alkaloid of wide use, *viz.* :—hyoscyamine—which is obtainable from the *Hyoscyamus niger*—the henbane of the English country lane. The writer recently had occasion to analyse a sample of Indian Hyoscyamus (probably the *Hyoscyamus muticus*—an allied species of the genus *Hyoscyamus*) grown in the Punjab where large quantities of the plant occur in the wild state along the river sides. The assay showed the dried plant to contain the very high amount of 0·827 per cent. of mydriatic alkaloids. This is very much richer than the English henbane, in fact it is nearly ten times as strong. Specimens of Indian henbane have been known to contain as much as 1·28 per cent. of alkaloid and unlike the English variety *Hyoscyamus niger* which contains the alkaloids hyoscyamine, hyoscine, and scopolamine the Indian variety *muticus* is said to contain only hyoscyamine. As a source of this important alkaloid hyoscyamine Indian Hyoscyamus should receive the attention of the manufacturer of fine chemicals and drugs.

For the information of those readers of the Journal who are interested in the chemistry of this subject or the manufacture of hyoscyamine, below are given the details of the method of assay used, which is a modification of that devised by Rupp. (*Pharm.*

Zeit. 1908, 738; *Chem. Zeit. Rep.* 1908, 32 529; *Pharm. J. Russ* 1911, 138; *J. Pharm. Chem.* 1911, 3,551). The method can be used for assaying extracts of belladonna also.

Twenty-five grams of the powdered leaf are extracted with 300 cc. hot alcohol Sp. Gr. 0·829 in a Soxhlet tube (4 times was found sufficient to exhaust the leaves and obtain a washing free from alkaloids). The alcoholic extract is evaporated until a sticky brown mass is obtained. This is weighed and the weight noted. Six grams of the extract so obtained is weighed into a stoppered flask. About 5 cc. of water, 90 grams of ether and one gram of ammonium hydrate are then added and the mixture shaken for 15 minutes. After separation 60 grams of the clear ethereal layer is filtered off and the solvent evaporated. The residue is then treated with 5 grams of ether and again evaporated to dryness. This is repeated three times, each time with 5 grams ether. The residue is then dissolved in 5 grams of alcohol 70 per cent. and the solution transferred to a graduated 100 cc. flask.

The first flask is washed out with another 5 cc. of alcohol 70 per cent. and then with water. To the bulked washings is added 20 grams of sodium chloride and 20 cc. of N/100 HCL are added with sufficient water to bring the whole contents up to 100 cc. After thorough agitation the solution is filtered. 50 cc. of the filtrate is transferred to a stoppered flask. 30 cc. of ether and 5 drops of Iodeosine indicator are added. The excess of hydrochloric acid is then determined by titration with N/100 KOH in the usual manner.

In the meantime a blank experiment *with the same reagents* but without any extract of the leaves, is performed to obtain the correcting factor for reagent impurities, and this is deducted from the above titration figure. This precaution is absolutely necessary as a correction of upwards of 2 cc. of N/100 HCL is frequently found.

Each cc. of N/100 HCL used by the alkaloids = 0·00289 of mixed alkaloids as hyoscyamine.

This is not the first time that Indian Hyoscyamus has been examined, for Dunstan and Brown examined a specimen (*J. C. S.* 1899, 75,72), but only 0·1 per cent. of alkaloid was then recorded.

It is possible that more than one variety of Hyoscyamus exist and that the alkaloidal contents of the varieties differ considerably. It is also more than likely that the amount of active principle present will depend upon the age and condition of the plant, for Godamer (*Arch. Pharm.* 1898. 28), has shown that in *Hyoscyamus muticus* the stalk contains 0·49 per cent., the leaf 0·9 per cent., and the seed capsule 0·585 per cent. of alkaloid.

Previous to the outbreak of the present war not only was a large proportion of the drug grown in Germany but German chemists practically held a monopoly for the manufacture of the alkaloid.

If then the supply of this substance falls short of the demand, English manufacturing chemists can obtain an adequate supply of the raw material from Northern India, for the plant can be exported in the dry state without impairing its value for alkaloidal manufacture.—(J. H. Barnes.)

⁂

In view of the present cross-breeding experiments being carried on in the various dairy farms and milk centres of India with various breeds of English cattle, the 1914 Year-Book of the British Holstein Cattle Society is of great interest. It is clear from a glance that this breed is now the foremost of its type, a type which is undoubtedly the most useful for all-round purposes.

It gives an enormous quantity of milk with an average yield of 3·30 per cent. of fat. This, while low in comparison with the Jersey's 5·13 per cent. and the Guernsey's 4·87 per cent. when taken in comparison with the average milk yield per day of the three breeds, works out strongly in favour of the Holstein which gives 48·9 lb. of milk per day to the Guernsey's 28·9 and the Jersey's 24·5, while the Ayrshire whips in with 3·85 per cent. of fat and a daily yield of 27·7 lb.

These figures total up to an *average daily fat yield* of

lb. 1·61 from the Holstein,
,, 1·41 from the Guernsey,
,, 1·26 from the Jersey,
,, 1·07 from the Ayrshire,

which points to the undoubted fact that the Holstein can hold its own with any breed over an entire day's average, although the fat content is undoubtedly lower in any given sample of milk taken from it; for when one compares a 600-gallon cow giving 5 per cent. fat with a 900-gallon Holstein giving only 3·5 per cent., you get a balance of fat in favour of the Holstein over a year's working of some 15 lb.

The fat globules of Holstein milk are very small and the milk is naturally easy of assimilation. It is therefore especially suitable for the feeding of infants. This fact is very well appreciated in the United States of America.

The Holstein is a large, vigorous animal, yet docile and gentle. She is a real genuine ranger and will pick up a living anywhere, while her constitution is thoroughly sound and her calves hardy and strong. She also breeds to a good old age and milks freely to the end, while when dried off she fattens up rapidly, being devoid of that curious inability to fatten which is characteristic of so many milk breeds. It would therefore seem that in this country where the cow that gives very little milk with a high percentage of fat is all too common an out-cross with this vigorous breed is bound to do much good, for the size of the Holstein and great breadth and strength compared with the angularity shown by the usual milk breed should make the bull-calves grow into excellent draught animals and it is obvious that the milch stock with such enormous records behind them, 1,000-gallon cows being quite common now, cannot fail to become milk producers of the first class, as in the whole breed there is ingrained a hardiness of constitution unimpaired by any extensive in-breeding for Show Yard purposes which undoubtedly undermines and brings to a speedy close the careers of so many first class bulls out here.

This breed is descended from Friesian cattle, one of the several groups of Dutch cattle imported into England. It may be mentioned that Dutch cattle have been instrumental in the development of the dairy herds in many countries and prosper even in the Arctic regions of Russia. They are most famous in America where the importation of pure bred cattle has been considerable. In

South Africa these cattle are very widely distributed over the Cape and Free State Provinces and over the Transvaal. New Zealand and Japan are now importing great numbers of Friesian cattle, and taking into consideration the number of different climates they have proved a success in and the diseases they have been proof or almost proof against, no greater testimony can be paid to their universal hardiness and suitability for all countries.

It would seem therefore, that we should give an extended and careful trial to this extraordinarily useful breed, which may have the power of benefiting our dairy work to a considerable extent.—(WYNNE SAYER.)

REVIEWS.

The Score Card System of Dairy Farm Inspection.- Published by the National Clean Milk Society, 2, Soho Square, London. Price 6*d.*

This pamphlet is based on the American method of controlling dairy inspection by means of score cards enabling the Government to see at a glance in which particular the dairies of the country fail and what steps can be taken to improve the methods at present in vogue—and where legislation will have a beneficial effect in maintaining the purity of the milk. The score card for the inspection of dairy farms is designed to direct attention to all the essential details in the production of clean milk and indicates from the proportion of marks allotted the relative importance of each item in relation to the conditions as a whole. It sets up an ideal standard for a producer of milk. The division of the card into columns for equipment and for methods enables a farmer to realize more clearly whether the improvement of any condition is within his power or not. In the United States of America the system is not confined to the inspection of farm dairies but different score cards are also used for wholesale milk dealers' premises and for retail milk shops.

This system of inspection will be appreciated more and more as people realize that the cleanliness of milk is of greater value from the point of view of health than its chemical composition and that this cleanliness is promoted by the production and handling of milk under sanitary conditions.

At a first glance it would seem that the card aims at an impossible perfection—at least for India—but there is little doubt that any Indian dairy which could get 10 marks out of the possible 100 would be a phenomenon. It would seem that the health of cows and cleanliness of utensils and attendants are the places where an attempt ought to be made to at least colourably imitate the millennium advocated in the pamphlet. It is obviously not going to be easy to have the well drained and well situated cowsheds advocated, and it would seem best to do all that can reasonably be accomplished with the material in hand, and after all to get milk from a healthy cow drawn by a clean pair of hands into a clean utensil is making a very great advance on the conditions which are all too prevalent nowadays. It is when the milk and dairy industry becomes properly organized that we shall get properly built and properly drained cowsheds which will be a natural adjunct to a large and properly conducted milk business. At present the best we can do as regards buildings is to collect the *gaolis* of any particular town and put them up a building under the co-operative scheme where they can be controlled; any individual effort would be doomed to failure. There is, however, in the pamphlet an interesting paragraph on the small top milk pail to which on the score card what may seem an unduly high percentage of points is given. But on examining the results of tests it is seen that no single improvement has produced such a beneficial effect on milk cleanliness. It is here in the purchase and use of such utensils that much can be done towards attaining a moderate standard of cleanliness which will, it is hoped, be the forerunner of an era of cleanliness which must supersede the present methods of the *gaoli* if the health of the country is going to improve, for it is difficult to imagine a greater danger to the infant life of India than the present state of dirt and dishonesty which seems inseparable from milk and its purveyors.—(W. S.)